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DECEMBER 1985 95p

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Radio tuning by home computer

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MicroGrasp is a fully programmable electric robot arm with closed loop feedback for positive positioning. The robot can be driven from virtually all micros.

Robot kit with power supply **£150** + VAT

Universal interface board kit **£42** + VAT

Put the kit together, plug into your micro and off you go!

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Complete kit **£40** + VAT

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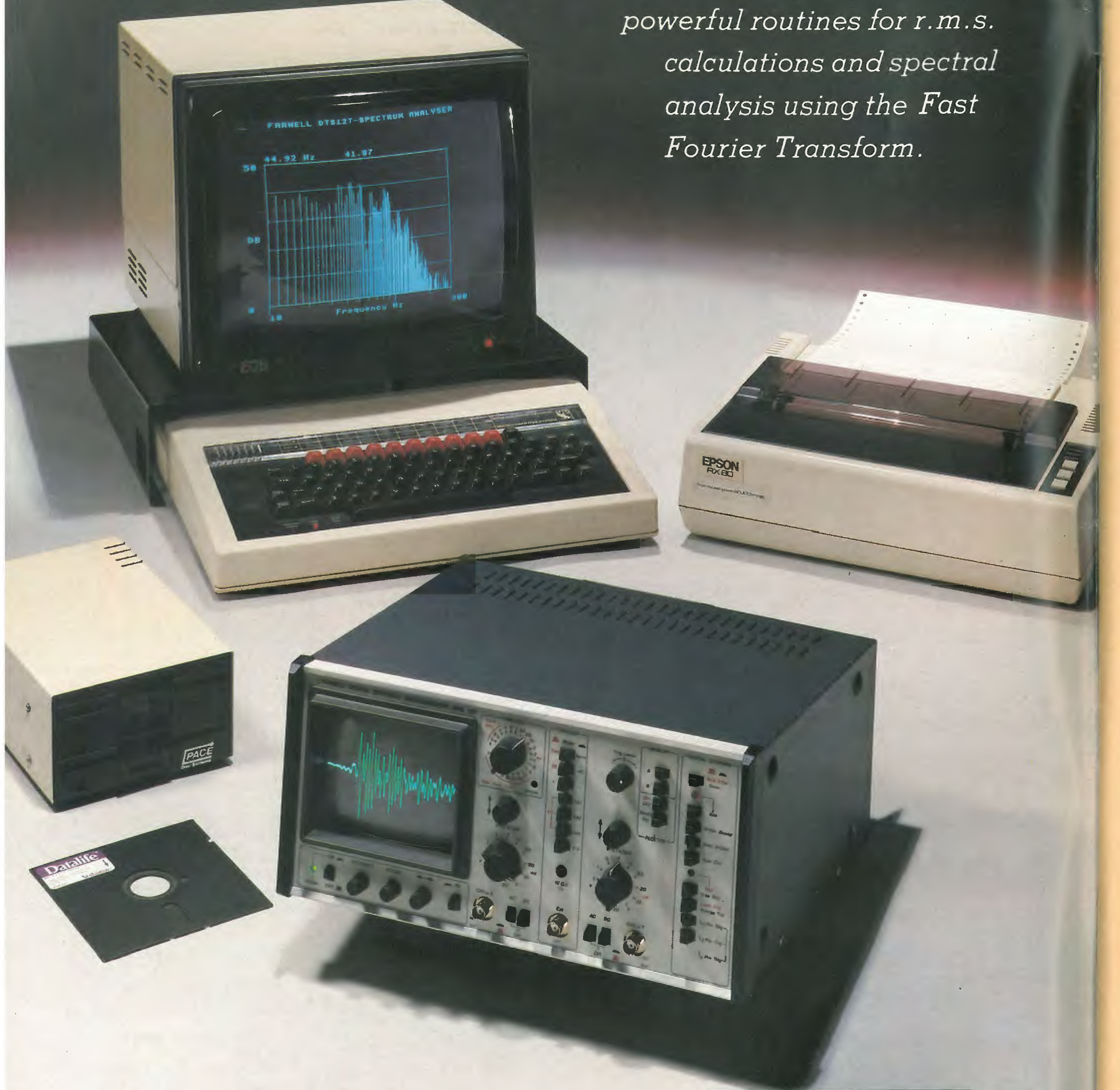

...the DTS12T from Farnell

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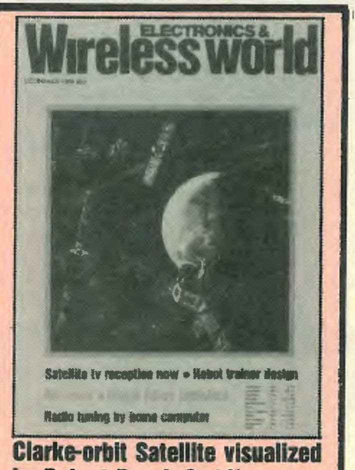
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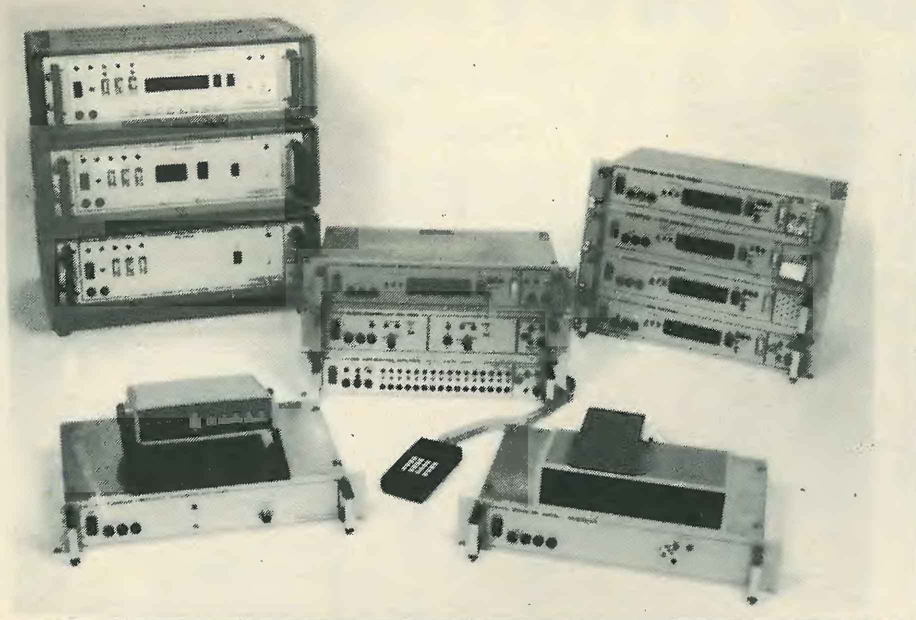

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6½in	25	4 or 8	Audax	Woofer	£7.50	£1
6½in	35	8	Audax	Bextrine cone wooder	£17.50	£1
6½in	30	8	Goodmans	Hi-Fi Twin Cone Full Range	£7.50	£1
8in	20	8	Far East	Hi-Fi Twin Cone Full Range	£5.95	£1
8in	25	4	Goodmans	Woofer	£7.50	£1
8in	30	8	Wharldale	Roll Surround Woofer	£9	£1
8in	30	8	Audax	Hi-Fi Woofer	£7.50	£1
8in	50	8	I.M.F.	Ribbed Betrine Cone Wooder	£16	£2
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8in	60	8	Sound Lab	Hi-Fi Twin Cone Full Range	£14	£2
8in	60	8	Goodmans	PA & Hi-Fi Systems	£14	£2
10in	30	4 or 8	Far East	Bass Woofer, Hi-Fi	£14	£2
10in	50	8	SEAS	Bass Woofer, Hi-Fi	£19.50	-2
10in	20	8 or 16	Celestion	Disco PA	£15	£2
10in	50	8 or 16	Baker	Disco – Guitar – PA	£18	£2
10in	50	8 or 16	Celestion	Disco – PA	£21	£2
10in	60	8	Soundlab	Twin Cone Full Range	£19.50	£2
10in	300	8	WEM	Woofer	£36	£2
12in	30	4 or 8 or 16	Baker	Twin Cone Full Range	£18	£2
12in	45	4 or 8 or 16	Baker	Disco – Guitar – PA	£18	£2
12in	80	8	Baker	Bass Woofer	£25	£2
12in	75	4 or 8 or 16	Baker	Disco – Guitar – PA	£22	£2
12in	100	8	Goodmans	Woofer	£30	£2
12in	120	8 or 16	Goodmans	Disco – Guitar – PA	£34	£2
12in	100	8	H – H	PA	£39	£2
12in	100	8 or 16	Baker	Disco – Guitar – PA	£28	£2
12in	150	8	Celestion	Disco – Bass Guitar	£85	£3
12in	200	8	H – H	PA Disco	£69	£3
12in	300	8	WEM	Woofer	£44	£2
15in	100	8 or 16	Baker	Disco – Guitar – PA	£39	£3
15in	100	4 or 8 or 16	H – H	Disco – Group	£49.50	£2
15in	250	8	Goodmans	Disco – Group	£74	£2
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18in	250	8 or 16	Celestion	Disco – Group	£110	£4

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LEVELL RC OSCILLATORS TG200D/DMP £130/165
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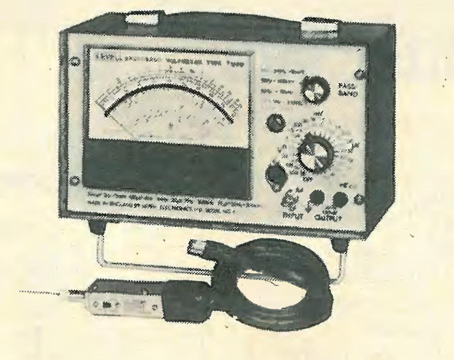

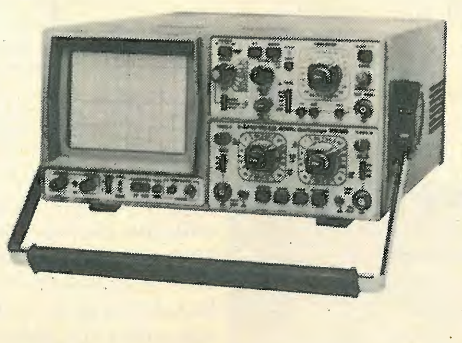

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320K: 0-30V at 0-2A, 0-30V at 1A & 4V-6V at 7A.

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3031: CRT 1kV 5x7cm. 3036: CRT 2kV 8x10cm.

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CROTECH DUAL TRACE 30MHz (@5mV) 3337/39 £425/570
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3339: VDU mode. Component tester. DC outputs.

HAMEG DUAL TRACE 20MHz (@2mV) HM203-5 £270
2mV-20V/cm. Ch2± Ch1. X-Y. Cal 0.2V/2V 1kHz sq. 20ns-0.2s/cm. Auto, normal or TV trig. Component test. CRT 2kV 8x10cm. Long decay CRT £25 extra.

HAMEG DUAL TRACE 20MHz (@5mV) HM204-2 £365
1mV-50V/cm. Ch2± Ch1. Sig delay. X-Y mode. Y out. 10ns-1.25s/cm. Sweep delay 100ns-1s. Cal 0.2V/2V 1kHz/1MHz. Z input. Comp. test. CRT 2kV 8x10cm.

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HITACHI BATTERY DUAL 20MHz (@5mV) V209 £680
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CIRCLE 37 FOR FURTHER DETAILS.

Who should market satellite TV

In October of 1979 a group of the first seven owners of home-constructed satellite earth stations got together and ran a seminar. Those who attended went home to their garage workshops and kitchen tables from where the satellite industry of the USA started. Many of the major multi-million pound companies started there in 1979. Now, there are over a million home satellite stations, with sales estimated at four million units this year — a major market.

The American experience shows that those still in the business five years on were the *technical* people that were in at the start. No doubt there were a few fast-buck merchants, but their names are well forgoten.

The UK should learn from its transatlantic cousins, says John Standen of North East Satellite Systems and author of the article starting on page 60, who feels that if satellite tv is marketed through the technically inexperienced the public will receive an inferior result which could set back this new technology by several years. "Sales of satellite tv equipment should be made from a small network of qualified technical people with a genuine interest in the technology rather than a group of 'in it for the money' organisations who do not know a transistor from a London Bus." The market for the uninitiated must wait for d.b.s., he says, where the power level is so high that reception is just about possible from an open-ended waveguide pointed in roughly the right direction!

Transputer — a little late but fast enough

After a year's delay, Inmos Transputer evaluation boards are finally in the hands of distributors, but individual processors are not expected to be available until January.

Between £5 and £10 million has been invested in the Transputer project from a total Inmos investment of around £100 million. Although the processor technology was developed in the USA the device architecture is of UK origin. Manufacture is taking place in Newport, Gwent.

Despite this investment Inmos is not prepared to speculate about sales, using the argument that the Transputer is a new product and occupies a new market. 'We intend to leapfrog the competition' says Inmos leader Iann Barron.

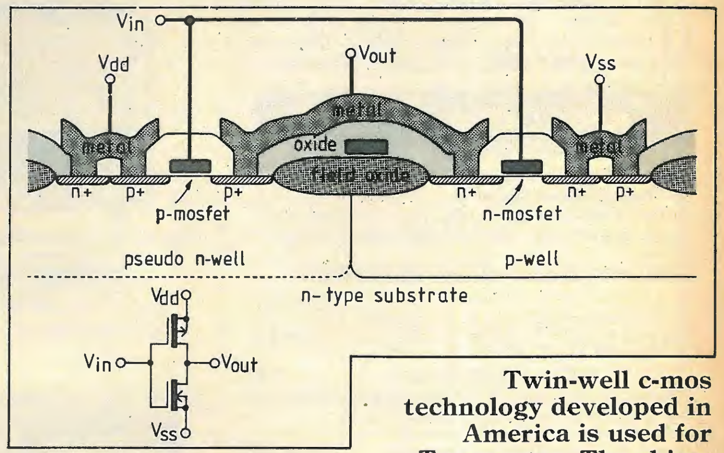
Transputer strategy, says Inmos, is to avoid direct competition with Intel and Motorola and 'be a DEC not an RCA'. There was no shortage of comparisons with the Motorola 68000 processor and its markets at the launch though — Iann Barron went as far as to say that Motorola and Intel are the company's main competitors. It was also said that the Transputer has not only the market of all of the other processors but others' new ones too.

Inmos speed and efficiency comparisons show that the Transputer outstrips the competition. But this completely new device operates in a different way to conventional processors which makes it difficult to judge the real value of these comparisons. Two things seem clear though — it is easy to run many Transputers in parallel and performance increase is directly proportional to the number of processors used. This is not the case with conventional processors.

Motorola's European Product Marketing Manager Ray Burgess feels that the Transputer's market is certainly not the same as that of the 68000 and that it will never replace the general-purpose processor. "It's unlikely that you will find a Transputer at the heart of a large workstation" he says. "Of our high-end users, not one has considered using the Transputer instead of the 68000." But it is early days yet.

Inmos says that the lack of a second source is not a problem but Burgess disagrees, asking "Which large manufacturer would take the risk?" A second source for the Transputer is not expected until the second quarter of next year. "Viability of the vendor is also an important factor to a large company when choosing a processor" he added.

Asked who would use the device, Burgess said that it would be used by universities and people who didn't have to justify research costs. He says that the Transputer will compete more with new signal-processing devices rather than with general-purpose processors, finding applications in graphics terminals and voice and signature analysis.



Twin-well c-mos technology developed in America is used for Transputer. The chips, each holding 200 000 transistors, are made in Newport, Gwent.

Transputer technology

Unlike conventional computers which execute programs sequentially, the Transputer executes programs concurrently, which means that many steps of the program can be run at once. The device can be used on its own, but its *forte* is in multi-processor applications. The processor has special communication links for connecting to other processors of the same kind.

Internally, the Transputer uses reduced-instruction-set computer architecture which is said to allow high performance on a small silicon area. Simple operations like addition and subtraction take 50ns and more complex operations like scheduling take less than 1µs. Average operating speed is 10 million instructions per second. The instruction set is designed for executing compled programs and all instructions are one-byte long which means that programs are compact.

The Transputer can be programmed in standard high-level languages like C, Pascal and Fortran, but to exploit its concurrent properties, a language called Occam is used. This language has been available for more than two years (News, Feb. 1983, p.37). Programs running on a single Transputer system run twice as fast on a dual-processor system without software modification because of the nature of the software and architecture of the processor.

One particular area of interest is in so-called fifth-generation computers, say Inmos, where the Transputer is already being used in a number of experimental systems.

HDTV is coming

On the set of *Onirico*, an experimental programme made by RAI Milan using Sony h.d.t.v. equipment

High definition television is definitely on the way. That was the message brought by Stuart Sansom of Sony Broadcast when he demonstrated his company's system in October to a meeting of the Royal Television Society and the BKSTS. The first broadcasts will come from NHK in Japan, who intend to begin a direct satellite service in 1988.

Enough equipment is available now for the Japanese 1125-line standard to make up a more-or-less complete broadcasting chain. In Sony's demonstration set-up were a video recorder, a camera, a mixer, a large-screen three-tube projection tv and c.r.t. monitors in sizes up to 28 inches. Equipment elsewhere includes standards converters and telecine. And tape-to-film transfers have become possible through an electron beam recording process developed by Sony. Mr Sansom also revealed that laboratory prototypes of an 1125-line domestic video recorder are already in existence.

The picture aspect ratio of Sony's system is 5.33 to 3 and the information content about five times that of a conventional 525/60 NTSC signal. The choice of format was guided by the need for compatibility with the cinema; the picture is much wider than the 4:3 aspect ratio of present-day tv broadcasts.

Sony's system is based on research findings* published in 1982 by NHK, the Japanese state broadcasting organization. The 1125-line standard was picked as representing a level of resolution beyond which improvements were was unlikely to be visible under practical conditions.

Mr Sansom explained that the large screen was intended for fairly close viewing, at a distance of two to four times the picture height. Although only the central portion of the eye's retina had sufficient resolution to take full advantage of the high definition, it had been shown that a larger image was essential for creating an illusion of realism. The field rate of 60Hz, with 2:1 interlace, was found adequate to overcome the flicker associated with large high-brightness pictures.

Recordings shown by Mr Sansom included a demonstration tape from NHK featuring excerpts from the opening ceremony of the 1984 Los Angeles Olympic Games, moments from a selection of Japanese variety shows and some wildlife scenes. Although the recordings were third or fourth-generation analogue tapes, clarity and colour quality were very striking — every hair on the squirrel seen cracking nuts was sharply resolved. Line structure on the display could be seen only by peering closely at the screen.

Also shown was a short experimental production made by Radiotelevisione Italiana using equpment provided by Sony. The programme, a wordless melodrama entitled *Onirico*, was shot largely at night with the aim of showing any shortcomings of the system. High-contrast pictures showing car headlamps in the dark street were realistically handled, though it was noticeable that actors who moved in front of a light source became transparent for an instant. However, Mr Sansom indicated later that lag and other problems caused by electronic camera tubes could be expected to disappear as solid-state devices took over.

The audience also saw *Onirico* in a 35mm film transfer, which made it plain that the 1125-line picture is potentially quite good enough for originating cinema material. The main defect was a characteristic shudder on movement. This, according to Mr Sansom, was a result of conversion from the 60Hz field rate of the original, and could be reduced by improvements in the process. He mentioned some Canadian research which had shown that the high resolution of which 35mm cine film was capable was never realised because of unsteadiness of the frame in the cinema projector: the real resolution never exceeded about 700 lines.

One drawback of the Sony system is the enormous bandwidth needed for its transmission: 20MHz for luminance, 7MHz and 5.5MHz for chrominance. However, Sony has devised a compander system named Muse, which can squeeze the signal into a standard satellite channel and will be used for the forthcoming NHK service.

What about Europe? The CCIR has been meeting in Geneva to discuss a possible world standard. But Mr Sansom believed that agreement was unlikely to be reached quickly and that countries with existing 60Hz systems would probably go ahead with the Japanese standard.

Asked about the issue of compatibility with existing terrestrial tv standards, he told his audience that satellite interests would soon dominate the television medium and that the day of the terrestrial broadcaster was nearly over.

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*Technical Monograph No. 32, Nippon Hoso Kyokai 1982.

The IEE Faraday lectures this year are to be given by British Telecom on the theme Beyond the telephone: the intelligent network. Bill Jones, BT's chief executive of technology, is the senior lecturer and is assisted by the anonymous 'digital man'. As in previous years the lectures are a travelling road show intending to stimulate interest in the subject amongst young people, supported by the full works: Live demonstrations, audio-visual presentation, film and a number of special effects. Tickets: tel. 0462 5331

Testing centre for lans

Networking Centre is a private company set up to provide independant conformance testing and certification for the lower layers of the open system interconnection model for computer communication through local-area networks. (The o.s.i. standard is designed to allow information exchange between computer systems regardless of manufacture or geographical location.) The new company, initiated by Eosys, is funded through City backing and by the DTI. Technical collaboration is provided by Era Technology, who specialize in research and development and in testing, and further collaboration is expected from Kemo in the Netherlands and Tuv in West Germany, with additional funding from the EEC.

In addition to product conformance testing, the Networking Centre's services will include specialist technical advice, workshop facilities for manufactures who wish to develop conforming products, configuration testing to check that a particular combination of products will network satisfactorily, and a ian advisory service to help users resolve particular compatibility problems. The Centre plans to develop comprehensive test suites concerned with different ian technologies, the first expected by the end of 1986. The upper layers of the o.s.i. structure, concerned with wide-area networks, are in the care of the National Computer Centre who will undertake the conformance testing.

What's so different about risc?

Along with the production of the Inmos Transputer, and the Acorn Risc Machine (November issue, p.5), there is news of another processor, this time based on the Forth language. Dissatisfied with the performance of Forth on the usual microrporessors, Alan Winfield of Metaforth in Hull analysed the frequency of use of the Forth primitives and devised a processor which could execute the instructions directly. These no longer need interpreting into machine code for another processor; Forth *is* the machine code for the Metaforth MF16. The result is a superfast (6mips) single-board computer. Remarkably, the MF16 has no processor, the functions being built from advanced Schottky logic chips. A v.l.s.i. processor in the design stage will operate at over 10mips.

Winfield also told us that, having sorted out the priorities of the instructions, the computer virtually designed itself. This is the common factor between all three risc devices: Acorn designers started with a set of instructions and designed a processor that could implement them; similarly Inmos started with Occam before designing the Transputer. Such processes eliminate all superfluous instructions and allow the processor to concentrate on the fewer essential instructions needed to implement the language, hence the dramatic increase in speed and the ease of such concepts as multi-tasking. 'Software engineering' is a much-used phrase with a new meaning.

In brief

Brunel University has opened the first UK training centre for advanced measurement technology. The centre will provide undergraduate, post-graduate and post-experience courses, which will be available to trainees from industry as well as university students. The professorial chair has been endowed by Hewlett Packard, who have also donated a computer and software.

* * *

George H. Clark began making scrapbooks in about 1888, at the age of seven, collecting anything to do with telegraphy and radio. By 1918 he had already accumulated 100 volumes of what he called *Radioana*. Working in the radio industry himself he became an acknowledged expert in radio history and was often used as an expert witness in patent infringement cases. He devised the 'type number system' for classifying thermionic valves while he was working for RCA. By the time of his death in 1950 he had amassed a collection which now takes up 84 metres of shelf space at the Archives of the National Museum of American History. The Smithsonian Institute has published a 90-page guide and index.

Cost-effective BBC designs

Engineering as a tool for eking out the licence money was very much in evidence during this year's open days at the BBC Designs Department. Several cost-saving designs were on display and some are already being taken up by outside manufacturers. The irony is that as an economy measure under the BBC's reorganization plans, the department itself is now threatened with virtual abolition.

"This project is calibrated in pound notes", said BBC engineer Robin Caine of his dynamic carrier controller unit for a.m. radio. Pound notes are yet another endangered species; but a.m. companding, it seems, can save coins just as effectively.

The idea is to reduce the modulated output of a transmitter when the modulation depth increases. The new unit, intended to be used with a Marconi B6034 transmitter, produces up to 6dB of audio compression at 100% modulation, plus an accurately-tracking d.c. output to control the carrier level.

At the receiving end, the signal is expanded by the set's a.g.c. Some signal-to-noise ratio is lost when the programme is loudest, but at such times a little noise is hardly noticeable.

Although the compressor time-constant at the mitter may not match the a.g.c. in the receiver, any imbalance will not be serious because the amount of companding is small. But the benefits could amount to an 8kW power saving on each 50kW transmitter, or some £150 000 if the process were applied to the whole Radio 2 a.m. network.

Still greater savings could be made at the BBC's short-wave stations, where transmitter powers are very much higher. Alternatively, the technique could be used to bring listeners a wider dynamic range: at present, the BBC's audience abroad receives a signal flattened out by some 16dB of limiting.

Dynamic carrier control was tested on Radio Bristol last year with good results, and four modules are now being made ready for operational use at Brookmans Park near London in January.

Another new unit likely to enter service soon is a television transmitter demodulator, a device fitted to the output of the station to pick off signals for measurement and monitoring.

The latest model incorporates a synthesized superhet receiver with its i.f. at the unusual frequency of 40.75MHz. The reason for the choice is that, with System I transmit frequencies, putting the oscillator on the high side of the input leads to oscillator frequencies which are exact multiples of 8MHz. So a synthesizer with simple division ratios and very low noise becomes easy to arrange.

Transmitter demodulators are hardly the sort of hardware that interests the ordinary viewer, but if these units were used throughout in the modernization programme planned by the BBC, the price-tag could be over £1M lower than for the bought-in equivalent.

Savings to the BBC this year

continued on page 87

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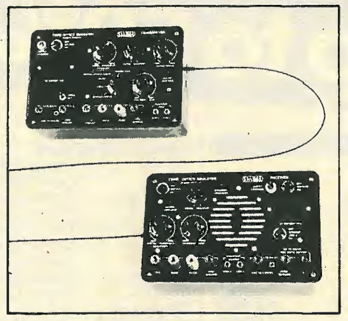

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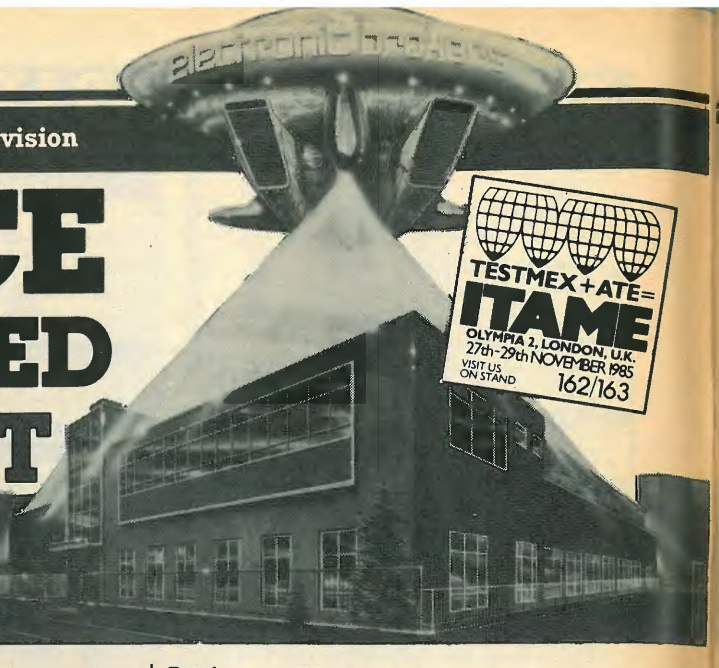

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CIRCLE 201 FOR FURTHER DETAILS.

Selling the spectrum?

The radio spectrum pricing study carried out on behalf of the Department of Trade & Industry (DTI) by CSP International is believed to have come out strongly in favour of a de-regulated, 'free-market' approach in which the right to transmit in bands of frequencies would be bought and sold, leased and sub-leased and open to all comers prepared to pay the going price.

Such a policy, if implemented, would clearly have profound effects on virtually all British users of the radio spectrum, including the operators of fixed (point-to-point) terrestrial links, land-mobile radio, broadcasting, defence and possibly even maritime and aeronautical communications and navigation.

Meanwhile, an only slightly less radical approach – a free-market 'spectrum renting' system retaining the power to dispose licences in the hands of a central authority – is being strongly advocated by David Russ of the Transport Science Policy Unit at the Department of Transport. At an IEE lecture on October 2, he argued that the introduction of the price mechanism would encourage users to reduce their demands for more v.h.f./u.h.f. spectrum by encouraging new technology and time-sharing, by reduction of e.r.p., by moving to less congested parts of the spectrum, by encouraging use of 'land-lines' and 'cable' rather than radio, and by pricing some applications out of the market causing users to abandon radio systems and discouarging others from starting operation.

Factors determining the 'rent' to be paid would include bandwidth required, position in the spectrum, effective power, geographical location, direction and route of fixed links and the duration of the agreement. He insisted the market-price of rentals would need to be determined and published and that the main users of the 'usable' spectrum – defence and broadcasting – should be included in the free-market system. International frequency agreements would need to be maintained only in so far as they affected international operation; he did not appear to have taken into account the many problems involved, for example, in operating communications transmitters in bands in which the prime users remain European television broadcasters, nor the long-term consequences of falling out of step in the frequency table with the other countries of ITU Region 1.

Similarly, David Rudd, like the 1982 Merriman committee, largely ignores the possible influence of the more spectrum-efficient 900MHz cellular radio systems and the increasing feasibility of 5kHz s.s.b. channelling on the future demand for land-mobile spectrum. Indeed he discounted cellular radio as a Rolls-Royce approach that may come to nothing.

Broadcasters and likely to be puzzled by his belief that, even after the loss of Bands 1 and 3, they still have more spectrum than they really need (for four-channel national u.h.f. coverage the broadcasters have repeatedly shown that they really require more than the existing 44 8MHz channels!). He conceded that few viewers would welcome an increase in the cost of tv licence that would be needed if the BBC were to be charged free-market rents and that the IBA would protest if the BBC alone were exempted. In practice, both organizations currently each pay about £1-million annually for transmitting licences, though this was not mentioned by David Rudd.

Only radioastronomers and radio amateurs, he suggested, would need to be exempted from spectrum renting. His arguments might have been more convincing had there been more evidence that the Department of Transport has a practical as well as a theoretical knowledge of the many problems of national and international spectrum management.

In effect selling or renting out the spectrum could amount to the first attempt to ahrness electromagnetic waves to revenue collection since the notorious Window Tax was imposed in 1691 and not finally repealed until 1851!

All at sea

The post-war development of weapons systems has often appeared – at least to interested outsiders – as a long series of abandoned, hopelessly delayed or vastly over-budget projects. Only the occasional successess have been hyped by all concerned in an effort to capture export markets; the many failures tend to get buried under a security cloak.

It is only recently that the sad saga of torpedo development has entered the public domain. As a result the Royal Navy, its weapons establishments, MoD procurement and the contractors have had to endure public criticism. In his forthright presidential address to the IEE, Admiral Sir Lindsay Bryson made no attempt to duck the issue. "All at sea" was an unusually apt title for his breezy assessment of the minuses and pluses of post-war development work on airborne early warning radar (absence of which in 1982 led to the loss of HMS Sheffield); torpedoes (16 out of 23 projects cancelled during development between 1945 and 1985); surface ships and the controversial long-thin/short-fat designs for Duke-class frigates. He could have mentioned, but didn't, the problem of p.v.c. wiring in conduits that resulted in toxic fumes.

Sir Lindsay roundly condemned cost-plus contracts, the separation of development and initial production contracts to different firms and the dangers of interference by government research establishments. He stressed the need for greater technical knowledge and expertise on the part of those who will ultimately have to operate the systems under emergency conditions. He noted, with evident regret, that the British Treasury refuses to accept the French dictum that "three francs spent at home, once recycled taxes are taken into account, is equivalent to one franc spent overseas."

His address pin-pointed reasons why so many projects involving electronics turn sour and suggested how these could be overcome in the future. The combination of complicated electronics and secrecy, the reluctance to make essential engineering compromises, and the extremely large sums of money involved, all seem to mitigate against the achievement within budget and time-scale of initial performance requirement that may well be beyond the capabilities, even if the system is technically successful, of those who may eventually use them.

There was, perhaps, in Sir Lindsay's barbed comments more than a suggestion that it is mainly those who never go to sea that are, figuratively, most at sea when it comes to research and development, weapons-procurement and the award of contracts to industry. He concluded that: "Engineering is above all about compromise, and it flourishes best in a competitive environment."

Early "radar"

Paul de Lattre, writing from Tilff, Belgium, comments on my notes in the September issue on the open publication of early radar experiments in *Wireless World*, as noted by Prof. Charles Süsskind. This reported on the obstacle detector tested on the French liner Normandie in 1935 and supplied by the Societe Francaise Radioelectrique (not "Radioelectronique", still an unknown word in 1935). He recalls that the unfortunate ship had to be taken out of service for a time after a disastrous trial run, owing to abnormal vibrations due to badly designed propellors. The obstacles detector was also removed.

He sent along a copy of a page from *Radio-craft* (August 1939 page 70) which had two photographs captioned: "Above, left, inventor Harry Dickens with his 'sensytrol'-power beam apparatus which was granted a US patent for power projection based upon radically new concepts in the

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field of electricity by the utilization of microwaves. This 'object-detector' requires no receiving apparatus at all for picking up the reflected wave. Above, right, Mr Dickens as he demonstrated his 'sensytrol' beam last month – over a distance of 14 miles! – at Floyd Bennett Airport, Brooklyn, New York City. The huge meter shown indicates hits. Some of its many uses: locating of aircraft above overcast clouds, spotting of icebergs or boats in a fog, detection of mountain ranges and other obstacles from airplanes, etc."

By August 1939, both Britain and Germany had developed practical radar systems operating over much longer ranges than the 'sensytrol' but it supports Paul de Lattre's view that "Before 1939, research on radio location of aircraft was aptly defined as 'a military secret', meaning something everybody knew about except the military. Another obstacle detector was described by Alan Fitzgerald in the *Journal of the Franklin Institute*, September 1936. Paul de Lattre is in fact not happy at the use of the term "radar" to describe "movement or displacement detectors" considering that such gadgets, like police traps, are more correctly called "cinemometres".

Amateur Radio

RAE again

In the October's Commentary I inadvertently ascribed the attack on City & Guilds' management of the Radio Amateur's Examination to Richard Harris, G3ZWH. This should have been Richard Horton, G3XWH – my apologies. Unfortunately, CGLI steadfastly maintains that its experience as "Britain's largest technical training body" justifies its strongly-disputed policy of not releasing any past examination papers for scrutiny or training purposes, not publishing its pass marks, not having a fixed-percentage rate and for not, apparently, regarding the examination as a qualifying examination akin to a vehicle driving test.

Surely CGLI should recognise that in practice a considerable number of those who provide instruction for the many RAE courses *have* been able to acquire or retain past examination papers thus giving their students an unfair advantage over others. Publication of papers that have actually been set, rather than the present "example questions" that appear to be far from representative, would also provide outsiders an opportunity to judge the quality and accuracy of the questions, and whether these reflect up-to-date amateur radio practice. Regrettably, as noted previously in this column, not all RAE papers have been of a standard that one would expect from the Institute.

DTI policy

Early this year, Ian Abel, G3ZHI submitted to the DTI a lengthy questionnaire seeking information on the policies being adopted on UK amateur radio licences. As a result the Radio Regulatory Division has produced for general consumption a detailed five-page 'Fact Sheet' on amateur radio licensing that defines the work of Branch 2 of the RRD in matters concerning legislation, enforcement and general policy, with the issue of the licences now computerised and contracted to the Post Office.

The fact sheet shows that changes to the amateur licence stem from regular three-monthly liaison meetings with RSGB representatives or are "stimulated internally, perhaps by suggestions from other parts of the RRD".

It is stated that no changes "of a fundamental nature" are being considered in respect of the Radio Amateur's Examination, and that Morse code will continue to be a requirement in the amateur service for the foreseeable future: "There is a desire amongst many amateurs to continue to use Morse, which is still regarded by many as the best mode of communication under extreme operating conditions. The vast majority of the national radio societies throughout the world also support the view that Morse code is a most desirable element both in the training of radio amateurs and in the operation of an amateur radio station. Knowledge of Morse is also important when using secondary user bands as a primary user may try to contact the amateur by Morse if the amateur is causing interference."

The fact sheet concludes that: "The Amateur Radio Licence fee is one of the least expensive, even within the category of licence taken out by hobbyist users of radio. In terms of the spectrum to which access is provided the amateur fee is very good value for money."

RSGB row

The dissention within the ranks of members and former members of the RSGB council and committees that surfaced at the 1984 annual general meeting has erupted once more. A call for a major reorganization of the Society has been made by several dissidents. They are calling for an extraordinary general meeting at which would be put a number of specific and far-reaching resolutions. Such a meeting requires the written support of at least 500 members. RSGB president, Joan Heathershaw, G4CHH, has appealed to members not to provide proxy forms to the opposition group, whose proposals she designates as "some tired old ideas".

The main sponsors of reform include Ingemar Lundegard, G3GJW, Geoff Smith, G4AJJ and Peter Crosland, G6JNS, and the main bones of contention include the belief that a trinity of Council and staff have gained undue domination over the Society's policies and activities, have imposed excessive secrecy on matters discussed at Council and committee meetings, have successfully blocked the emergence of new ideas and new faces, and have failed to stem a decline in the Society's publishing activities with the result that for the past two years expenditure has exceeded income, although the Society has strong financial resources.

The dissenting group are calling for limitation of the time members can serve on Council or committees, society elections and ballots to be independently supervised, and a subsidiary company to take over responsibility for publishing activities.

However, it seems inherently unlikely that the 'opposition' will succeed in pushing through their programme of reform, no matter how worthy their aims. Indeed, the most likely outcome may prove to be the strengthening rather than the loosening of the grip of the three individuals against whom the reform programme appears to be mainly directed. The unfortunate aspects for members is that such rows tend to result in large legal expenses.

In brief

The first St Albans (Verulam) Christmas Rally is to be held on Sunday, December 1 at St Albans City Hall from 11 a.m. to 5.30 p.m. (details Hilary, St Albans 59318) . . . Derby and District Amateur Radio Society, which incorporates the Derby Wireless Club formed in 1911, claims to be the oldest local radio club in the UK celebrates its 75th anniversary during 1986, starting off with a reception hosted by the Major of Derby in the Council House on 8 January, 1986 when an amateur station will be established that will endeavour to contact 'twin linked' cities throughout the world. The Society is planning at least one anniversary event per month from different locations within the City of Derby using the call sign GB3ERD . . . Amateur operation along the South and East coasts continues to be hampered by the Syledis radio-positioning system which is operating on an extensive scale in this shared band . . . The excellent new DTI publication "How to improve television and radio reception" and dealing with questions of radio-frequency interference became available without charge from main Post Offices in early October.

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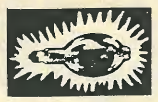

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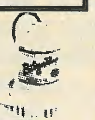

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200	16.47	2.36
250	19.92	2.77
350	24.64	2.84
500	30.69	3.10
1000	55.65	4.70
1500	71.79	5.95
2000	86.38	6.35
3000	121.12	OA
6000	258.77	OA

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100	11.88	2.10
200	16.47	2.36
250	19.92	2.52
350	24.64	2.84
500	30.69	3.10
1000	55.65	4.20
2000	86.38	5.50
3000	121.14	OA
6000	258.77	OA

24/12V or 12-0-12V
2×12V Secs. pri. 240V

12V		24V	Price	P&P
0.3A		15	2.53	90
1		05	3.45	1.30
2		1	4.46	1.36
4		2	5.15	1.70
6	A	3	8.07	1.76
8	M	4	9.43	1.82
10	P	5	10.31	2.05
12	S	6	11.43	2.15
16		8	13.62	2.33
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1		2	9.38	1.52
2	A	4	15.42	2.31
3	M	6	18.68	2.52
4	P	8	23.84	2.60
5	S	10	33.84	3.36
6		12	42.38	3.68
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2×25V Tap Secs Volts available 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33,40.
20-0-20 or 25-0-25V

50V		25V	Price	P&P
0.5		1	4.34	1.47
1		2	5.28	1.50
2	A	4	9.12	1.94
3	M	6	10.36	1.96
4	P	8	14.80	2.22
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60V		30V	Price	P&P
0.5		1	4.93	1.58
1		2	7.51	1.60
2		4	9.66	2.00
3	A	6	13.96	2.10
4	M	8	15.91	2.31
5	P	10	20.11	2.36
6	S	12	22.95	2.78
8		16	32.26	3.20
10		20	37.55	3.47
12		24	43.28	3.68

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Sec V	Amp	Price	P&P
3-0-3V	0.2	3.26	.96
6×2	1A×2	3.12	1.30
0-0-9	0.1	2.72	.96
9×2	0.33×2	2.53	.96
8-9×2	.5×2	3.53	1.30
8-9×2	1A×2	4.48	2.31
15×2	2×2	2.53	.96
12-0-12	.05	3.11	.96
20×2	15×2	3.55	1.30
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30V		15V	Price	P&P
0.5		1	3.35	1.36
1		2	4.54	1.48
2		4	7.34	1.69
3		6	8.50	1.45
4	A	8	10.15	1.99
5	M	10	12.55	2.10
6	P	12	14.20	2.30
8	S	16	19.00	2.36
10		20	21.92	2.46
12		24	24.36	2.63
15		30	27.96	3.20
20		40	37.42	5.14

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500	13.96	2.34
1000	23.84	2.90
1500	29.58	3.35
2000	44.34	4.20
3000	75.22	5.10
5000	113.11	OA
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500	25.38	2.90
1000	35.43	3.97
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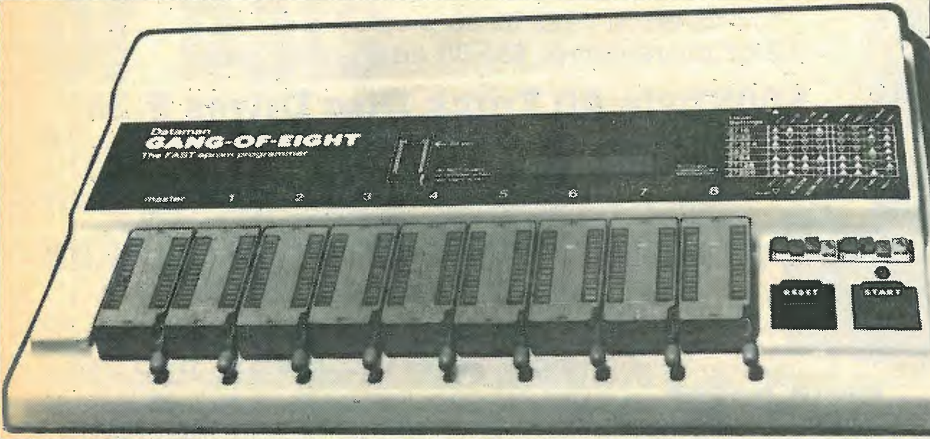

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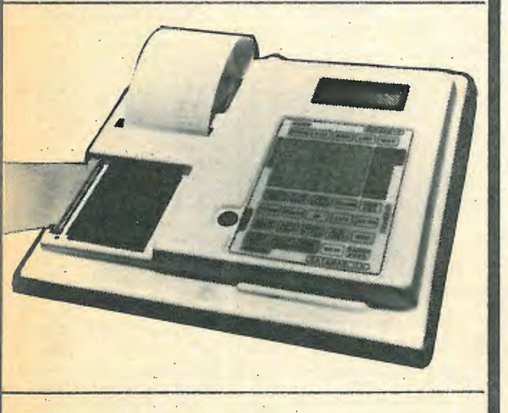

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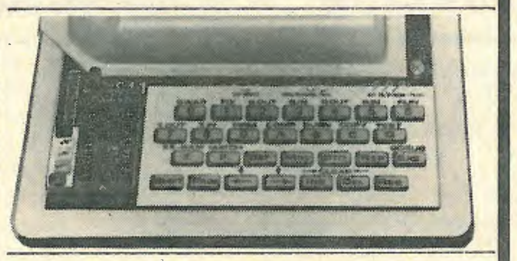

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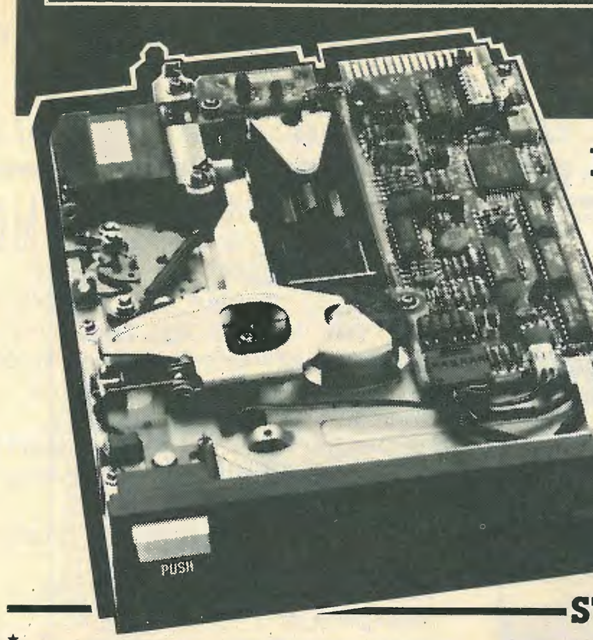

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3.0
3.3
3.6
3.9
4.3
4.7
5.1
5.6
6.2
6.8
7.5
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24
180
200
220
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300
330
360
390
430
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4.3K
4.7K
5.1K
5.6K
6.2K
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13K
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The sonar system of bats

Mechanical switching of tiny bones in the middle ear may explain the characteristics of bat sonars.

Yoshimutsu Hirata, Dr Eng.

Dr Hirata is a consultant specialising in acoustics and electroacoustics, living in Tokyo.

The sonar of bats is extraordinarily efficient and sensitive. According to Griffin[1], with a target diameter of 1cm and a detection range of 2m, big brown bats (Eptesicus fuscus) discriminate from background noise echoes very much fainter than the sounds they emit. The efficiency index is 2×10^9, which is as much as 10^{12} times larger than that of sonars contrived by man. They have a truly remarkable sonar system.

There is the question of why the detection range is so short. Since they discriminate very faint echoes – fainter than the sounds they emit by a factor of 2000 – it seems that they can detect the echoes returning from the farther range in a noise-limited environment. A bat will not chase a pebble, for example, tossed into the air if it does not reach the range of a metre or so. The answer to question gives a hint to understanding the most efficient and sensitive discrimination of bats.

There are many species of bats emitting differently structured ultrasonic sounds. Some bats, such as horseshoe bats, emit sounds which consist of a pure tone terminated by a brief f.m. component. Neuweiler and others[2] investigated horseshoe bats and disclosed the remarkable mechanical filter of the basilar membrane. They concluded that echo-locating bats have not invented something new, but simply exploit and refine the capabilities of the mammalian auditory system. Aside from the question of whether bats 'exploit and refine' their auditory system, the steeply-sloped filter (93dB/octave) of the basilar membrane in horseshoe bats is one of the important functions in finding insects and dodging obstacles without eyesight.

Such a filter, however, is not found in species that emit pulsed sounds over a wide frequency band ranging from as little as 16kHz up to 150kHz. Fig. 1 shows the spectrograms of orientation sounds of the big brown bat: cruising (a), beginning pursuit of an insect (b), and closing in on its prey (c), where the second harmonics are shown by curves above the frequency axis of 40kHz. As will be understood, the orientation sounds are composed of a steep downward frequency modulation. The echoes shown in (a) and (b), delayed about 30ms from the preceding sounds, are out of detection range. Fig. 2 shows the relation between the orientation sounds and the range of detection (2m) on a time scale, which leads to the suggestion that the ears of bats may have an alternation of receiving and non-receiving phases that synchronize with the transmitter. In contrast to humans, the larynx of a bat consists of a couple of thin-tensioned films which vibrate and generate sounds when the air from the air cell passes through them.

It is known that the middle ear muscles in humans are able to attenuate vibrations of the ossicles (tiny bones) which transmit the eardrum vibrations to the cochlea[3]. The

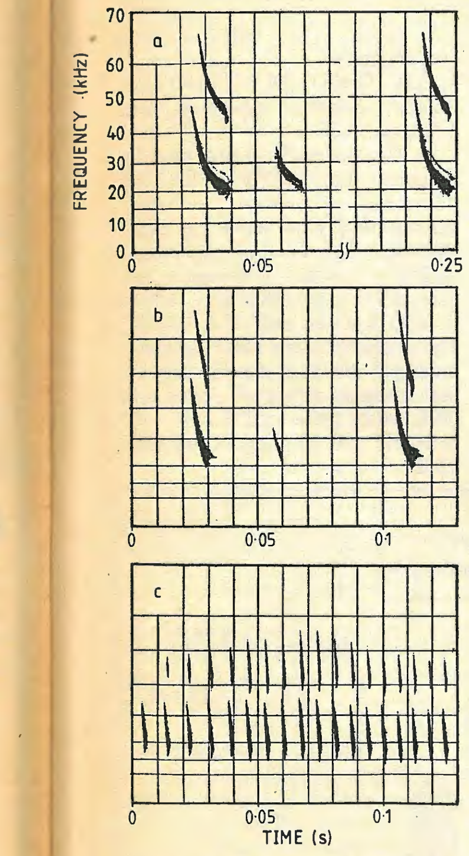

Fig. 1. Spectrograms of orienation sounds from the big brown bat (Eptesicus fuctus); cruising (a), beginning pursuit of an insect (b), and closing in on its prey (c). (From Griffin)

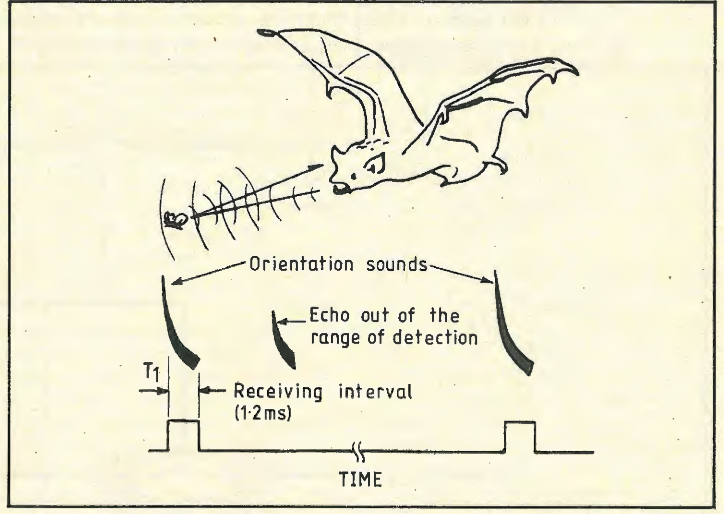
Orientation sounds
Echo out of the range of detection
T1
Receiving interval (1·2ms)
TIME

Fig. 2. Relation between the orientation sounds and the range of detection on a time scale. Delay time of echo returning from an insect at distance of d is 2d/c, which equals 1.2ms for d = 2m and c = 340m/s.

***Range divided by mass times power times target diameter.**

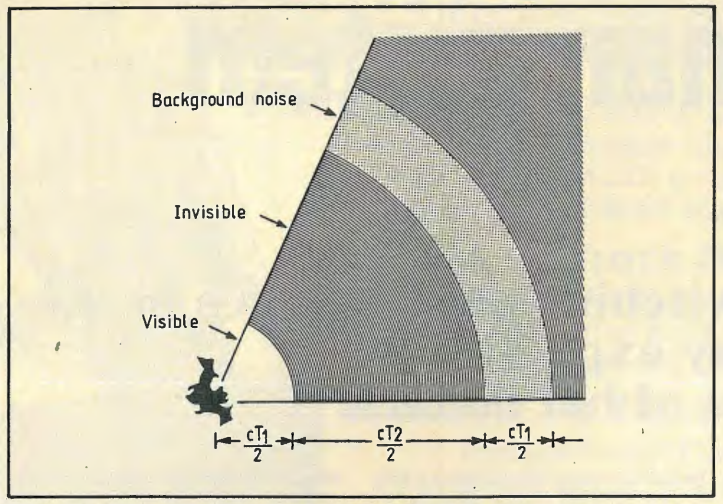

Fig. 3. Illustration of the 'sight' of bats using pulsed sounds. The range of detection is limited to within $cT_1/2$.

hypothesis that it is the mechanical switch of the ossicles controlled by the middle ear muscles which synchronizes with the transmitter (comprising the larynx and air cell) seems to explain why the detection range of bats is limited, as well as why bats can discriminate their own echoes in spite of the confusion of other's sound and an echo-cluttered environment. In a dark cave, hundreds of bats fly within the range of one another's sounds. Yet each bat can guide itself by the echoes of its own sounds.

Denoting T_1 as the receiving interval and T_2 the non-receiving interval, the rate of noise rejection is given by $T_2/(T_1+T_2)$, estimated to be 94% for case (a) 91% for case (b) and 86% for case (c). Further, the group of echoes returning from a prey in the range of detection has the pitch freuqency of $1/(T_1+T_2)$ which may discriminate echoes from click noise, *viz.*, the long-path echoes and other's sounds which fall into the receiving interval. Besides, as generally expected in other animals, biaural hearing together with the super-directional ears of bats must be used to localize the echoes.

Fig. 3 illustrates the 'sight' of bats using pulsed sounds, where the 'visible' area is limited within the range of $cT_1/2$, c being the speed of sound. The 'invisible' area lies from $cT_1/2$ to $(cT_1/2)+(cT_2/2)$, from $cT_1+(cT_2/2)$ to cT_1+cT_2 and so on, and the area of background noise due to the long-path echoes is shown from $(cT_1/2)+(cT_2/2)$ to $cT_1+(cT_2/2)$. The sonar of bats is suitable for the short-range target detection. The electro-acoustic analogue of the sonar is shown in Fig. 4, where the ossicles are illustrated as the switch that synchronizes with the pulse generator representing the larynx. It is interesting to recall that the middle ear muscles of bats are quite large compared with the case of other animals.[4]

Although there is circumstantial evidence, some direct measurements are necessary and are expected to verify the above hypothesis. In addition, if the bats have refined their ears in the process of evolution, it is also necessary to answer the questions of why they chose the difficult way of training their ears and larynx instead of training their eyes in the dark, and how it was achieved.

> However, ask, please, the domestic animals, and they will instruct you;
> Also the winged creatures of the heavens, and they will tell you.
> — *Job 12:7*

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3. M.E. Lutman and A.M. Martin, Development of an electroacoustic analogue model of the middle ear and acoustic reflex, *J. Sound and Vib.*, 64(1), 1979, pp.133-157.
4. Sound and Hearing, Time Inc., 1969.

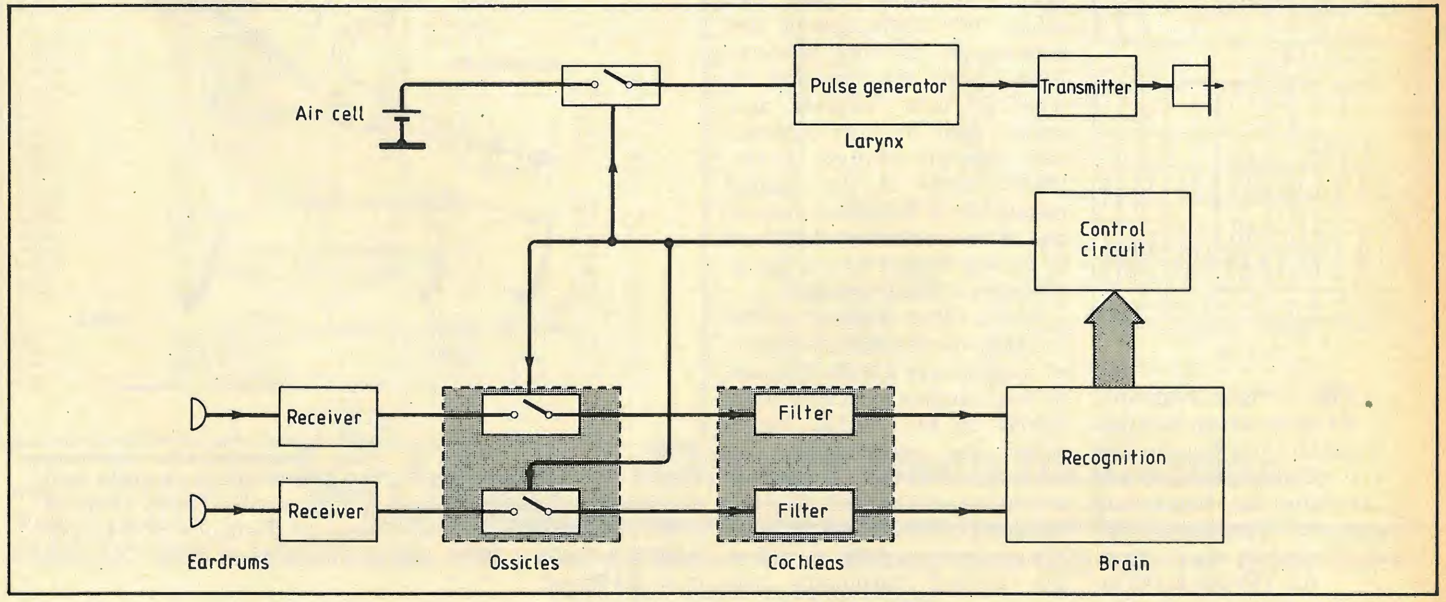


Fig. 4. Electroacoustic analogue of bat sonar, where the ossicles are illustrated as the switch that synchronizes with the pulse generator representing the larynx of the transmitter.

THROWAWAY REMARKS

I wonder whether any of your readers are suffering the same concern as myself over the present trend towards maintenance-free items, or extended interval maintenance in particular, as applicable to modern cars.

It is reported that television servicing may become a thing of the past: "When a major fault occurs you simply replace the whole set" (*Television* magazine, October 1985).

In days, unfortunately, past, if my car developed an ignition fault, a process of elimination might trace it to worn contact-breaker points which were replaced at the cost of a few pounds.

Recently, an ignition fault in my C.t . . . n was quickly diagnosed, by myself, as the "transistorized module" – an encapsulated item manufactured by Ducellier, which cost £79.13 and which, according to "C.t . . . nian" magazine is stocked in quantity by dealers.

Perhaps a reader may be able to provide a replacement in Circuit Ideas.

A. Hardcastle
Wandsworth
London SW18

SWITCH CURRENTS

Spotted yet again: the common fault of placing a capacitor directly across a switch, such as the reset button on microprocessor designs. This leads to very large currents flowing when the contacts are made, and bang goes the switch. It is good practice to use a series resistor of a few ohms, which will prevent failure.

I believe that this was pointed out in a *WW* of 1958 or thereabouts.

H. B. Finney
Cambridge

A QUESTION ABOUT 'Q'

In the *Quarterly Journal of the Royal Astronomical Society* (1985) 26, 51-52, I traced the history of Q, but failed to find where it first appeared in the literature. I have now a reference to a footnote in the *Bell System Technical Journal* (1930) 507, a paper by C.E. Lane, Phase Distortion in Telephone Apparatus; however Sir Charles Oatley tells me that he heard of it from Mr Scroggie as the ratio of reactance to resistance of a tuned circuit before 1927. Butterworth, *Wireless World* (1926) 754, calls this quantity Magnification. Can any of your readers quote an earlier reference to Q in an American or British journal?

Bartha Jeffreys
Cambridge

LIGHT CONVERSATION

I read Mr Rollemas' article on the German speech over light equipment with considerable interest as I was in charge of the Signals Experimental Group MEF, the unit referred to in the text, and as a physicist in uniform sorted out the optics. These were most interesting but my memory is that the head amplifier and main amplifier were rather poorly designed and were quite noisy.

We had harbingers of the unit a long time before the complete article was taken, in that at intervals the photoelectric devices came into our hands. They were of course a piece of red glass with a speck of thallium sulphide, all mounted with contacts in a plastic case. The first ones were handed to me as probable Tourmaline plates of the frequency recorded on the case. It was thought that the enemy had run out of quartz! They were soon identified and the number on the case seemed to be a serial number.

Later in the war I was sent from Cairo to examine some u.h.f. equipment on the island of Rhodes, when the enemy gave up in those parts. Apart from this I found a number of the Lichtspricht 80 devices which, according to the Germans, had been used over short distances for secure communication between strong points on hills and capes of the island. They differed very little from the earlier models, except that some extra baffles had been inserted to cut down scattered light.

The u.h.f. equipment mentioned above was on a quite high frequency for those days, some 300MHz, I seem to remember, and was the end link of a line through the Greek Islands, Greece, Corfu, Italy and finally the terminals at Vienna and Berlin. Its Rhodes station was on one of the peaks of Monte Profeta. It carried a speech circuit and a number of cyphered teleprinter circuits. In going to visit the station, myself and another signals chap read the map wrongly and strayed into a mine field from which we retreated most carefully.

Whilst we were finding out how the equipment worked something occurred which is a tribute to the RAF and their aerial surveys. An RAF man appeared in a Jeep and said could we confirm that the site was a radio station. We said, yes it was but how could he know as the aerials were tucked away in a cistern with a plastic face. Consulting his records he said that there had been a mast on the site earlier in the year. The Feldwebel left in charge was puzzled at first and then remembered that when the Captain had been in hospital in Rhodes Town the troops had got fed up with their comforts receiver which, like most army issue, had a very short range, and that they had cut down a pine tree and erected it on the site with a clothesline aerial, better to hear the dear homeland. The Captain, on his return, caused its removal saying the RAF would see it. It seems that not only did they see it but were ready to land 60 tons of bombs on the area in a few weeks' time.

You can't be too careful in war!

E.C. Vast
(Ex-Major, Royal Signals)
Hastings
East Sussex

ELECTRO-MAGNETIC PARADOX

Is not the motion of Mr Aspden's isolated electron a contradiction in terms? If it is truly isolated there is not even a reference frame from which its motion may be recognized, let alone the effects of that motion upon its non-existent environment, thus it can not possibly moderate anything at all. (Yes, I know I'm awful.)

More seriously, displacement current may perhaps be best thought of as the movement of catastrophe into a storage cul-se-sac for later release: it is not a true current being devoid of holes and having no closed loop. Its release would be a current.

A limiting sub-mass (LSM) is capable of spatial spin and thus of having a linear axis of rotation, and thus poles which are dimensionless points. Consideration of and by the poles is essentially statics, while consideration of and by the equator is essentially dynamics because the thing moves. A "field" of LSMs may be random or polarized: the latter case demonstrates linear polar electrostatics and spatial equatorial dynamics in simultaneous existence at right-angles, but only the dynamic dimension is capable of harmonic relationships.

Because an LSM can spin, its spatial integration can have spin "energy" which I suggest is indeed "energy": its axis, an unborn denizen, can not. I suggest that e.m. radiation is the linear transference of that energy with interaction between action and reaction, the universal precedent for evolution, interaction being faster than c. A photonic parcel then becomes a spinning LSM, and a collection of them can shunt in waves. It is not the waves which can be polarized but their constituents, by the refusal of constitutents of the filter to spin randomly, so precluding the possibility of the transmitted LSMs demonstrating harmonic relationships, a declinatory matter lacking in spectaculr sparkle or highlights.

An LSM is a product of catastrophe, postulated following the consumption of much creamed rice: if their axes coil themselves around a tree they are no longer straight, and the facts become distorted by their wriggling which causes an intermixing of high and low-energy LSMs better known as the rough and tumble of chaos with a current flow which tends to zero. The problem then becomes the creation of order once more, calling for a cessation of argument and much learning so that the axes may be brought into line: but it starts in abstraction.

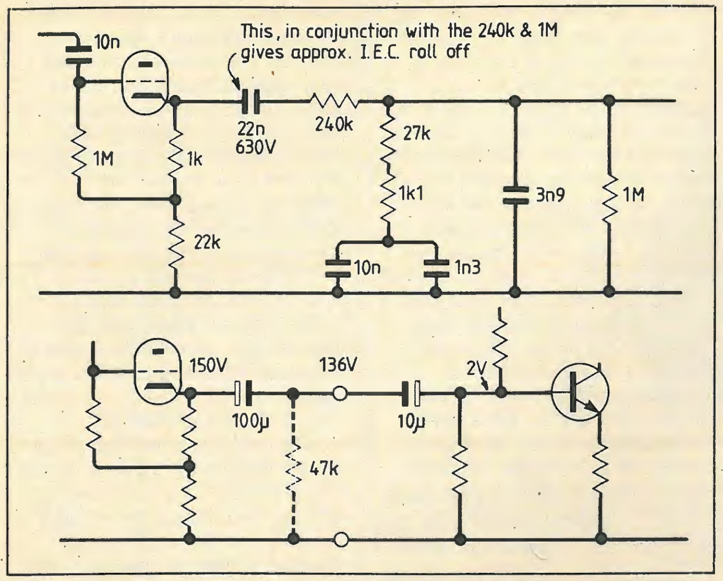
I would not expect a non-energetic displacement current to set up an energetic magnetic field any more than I would expect the cart to push the horse other than downhill, but I can see a non-energetic field co-existing with an energetic one which possesses dynamism, and I can see why artists paint pictures: the energy in a laboratory experiment remains only deduced, and it will always remain so even though it can be harnessed.

James A MacHarg
Wooler
Northumberland

VALVE DISC PREAMPLIFER

I read with interest the article by Richard Brice on a valve disc pre-amplifier. I agree with his basic assumptions and design philosophy but he had made some errors of calculation.

The 10nF capacitor in conjunction with R_1 (1MΩ) will not produce the 7950μ IEC bass roll-off. The Thevenin impedence seen by the 10nF capacitor is more of the order of 18MΩ due to the bootstrapping effect of the cathode follower. There is no need to change this — the IEC roll-off may be implemented elsewhere. His equalization is, unfortunately, incorrect. He has assumed that the equalization network sees only the 250kΩ resistors) (where do you get 250kΩ resistors)? In fact, it sees the Thévenin equivalent circuit which is the 250kΩ resistor in


10n
This, in conjunction with the 240k & 1M gives approx. I.E.C. roll off
22n
630V
240k
27k
1M
1k
1k1
3n9
1M
22k
10n
1n3
150V
136V
2V
100μ
10μ
47k

parallel with the 1MΩ resistor. An easy mistake — I did the same for months in blissful ignorance.

If we re-calculate the values of components in the equalization network we can also add the IEC roll-off. This has the added advantage that we can replace the 1μF electrolytic capacitor with a beter-quality component such as a polycarbonate. See diagram 1.

The only other changes I would make are of detail, the 1μF capacitor feeding the 250kΩ potentiometer could be replaced by a 0.22μF polycarbonate. The 1μF capacitor following could be replaced by a 10nF as used in the earlier stage.

The 100μF output coupling capacitor must surely be a bulky and suspect component; is it really necessary? The output stage should not be loaded by less than 10kΩ, so if we accept that as the minimum input impedence of the power amplifier, we find that 4.7μF would be an adequate value. It may be possible to use a non-polarized component here, but it would be expensive.

A word of warning, some transistor power amplifiers have coupling capacitors on their inputs with the laudable aim of preventing damage due to d.c. being applied at the input. Valve equipment always has an output capacitor to protect the following stage. Therefore connecting a valve pre-amplifier to a transistor amplifier should be safe. Occasionally this is not so; diagram 2 shows why.

The capacitors charge to equal values of charge, by applying Q=CV, we find that the small input capacitor of the amplifer has a large reverse voltage across it. It will fail quickly.

The solution is to add a resistor, shown dotted, or to remove one of the capacitors.

M. Jones
Shirley Warren
Southampton

SILICON DISC

The 'Silicon disc' design by J. Adams, published in the October issue, is certainly a good scheme for improving the response time of many floppy I/O bound programs and it also increases the amount of on-line storage available to the SC84 computer. However, with the extra memory configured as an extra logical disc (drive E), the system user must be especially careful to copy valuable files to 'real' disc before removing the system power. Also he is very prone to losing files through mains power failure. (In the rural area where I live, we lose the mains four or five times a year.)

An alternative approach, which uses exactly the same hardware, is to use the extra memory as a disc sector cache memory. With this system, when the disc driver routine is asked to read a sector, it first looks in the cache for the sector and returns the cache copy if found, else it must make an access to the physical disc to read the sector. Many algorithms for managing cache memories exist, and some are discussed in articles in *Byte* magazine, September, 1985.

The method I use is to hash all sector addresses to give a block number in the cache store. This gives a many-to-one mapping between all on-line disc sectors and the set of blocks in the cache. Upon disc writing, the sector data is also written to its cache block, overwriting previous data, and a directory field in the cache is updated indicating which physical sector is now held. Upon reading, the sector address is hashed and the appropriate cache directory entry is consulted. If the entry holds the desired sector addresses, which it (hopefully) generally does, then no physical access is required. In the same way as for physical writes, when physical reads are indeed required, then the data is also copied to the cache. The code to perform all of this extends the device drivers by about sixty bytes.

Disadvantages are that the increased on-line storage is lost and that a method of clearing the cache each time a diskette is changed must be implemented.

David J Greaves
Romsey
Hampshire

NICAD BATTERY CHARGER

I write to enquire about the series of articles by Rod Cooper on Nicad batteries. Perhaps you could forward the following questions.

- What are the relay specifications?
- Are there suitable alternatives to the Ferranti transistors in the 2N series?
- I cannot see the point in two diode strings in the comparators – surely one is enough, as used in the low temperature cut off.

I have enjoyed reading *Wireless World* since the early fifties and endorse the comments in Feedback column for September by Mr Beud. I hope *Wireless World* keeps a balanced viewpoint. The American market is flooded with pulp: so called technical magazines that are no longer satisfying the do it yourself hobbyist!

W R Risk, F.R.C.S.
Pontiac
Michigan

The author replies:
The relay I used on my prototypes was a miniature enclosed type with silver contacts rated at 3A, single pole. The coil was 100 rated at 6V but closing at 4.8V. These inexpensive relays can be found in the catalogues of several UK component suppliers and I am sure there are similar relays available in the USA.

Ferranti transistors were specified not just because they are dependable and British, but because this firm is particularly helpful when it comes to supplying technical data and advice – other firms could take a leaf out of their book. For American constructors, ZTX108B≡2N3903 and ZTX213B≡2N3905, both are compatible with the ready-made p.c.b. supplied by Biles Eng.

Regarding the diode strings, it would be possible to use one string as suggested by Mr Risk if the ambient temperature were to be held exactly steady. It was not envisaged that the charger would be used in a temperature-controlled laboratory however! In typical everyday conditions the ambient temperature fluctuations are very much larger than the 5°C rise produced by a fully charged NiCd cell at a charge rate of C/10, so this would produce false triggering of the comparator. In fact, single temperature-detection circuits are useless in such conditions.

What the second diode does is to keep track of the ambient temperature so that the comparator only triggers when there is a +5°C temperature difference between the two diode strings.

Even so, the tracking of the circuit is not perfect. With unmatched diodes, the circuit given is satisfactory for the climatic conditions in the UK, but may not cope with the extremes experienced in some parts of the USA, so it may then be necessary to match these diodes to get better tracking.

I must agree with Messrs Risk and Beud on the subject of computer projects. There is an unnecessary excess of these, not just in *EWW* but everywhere, and most display the sledgehammer-to-crack-a-nut syndrome.

FFT

The article on Fast Fourier transforms in the September issue* of *Electronics and Wireless World* ended with the hope that the article would be a source of inspiration for other readers. It certainly prompted me to resurrect some ideas I had for spectrum analysis which came about from trying to prove that there are always more ways than one of doing a job.

The programs I have seen for spectrum analysis have all been based on Fourier mathematics, so how could the same end result be achieved without recourse to such mathematics, or indeed knowledge of them? The following notes described one of my attempts using a BBC micro and simple basic.

An array of amplitude-sampled points store the waveform to be analysed, which may be input either through the a-d ports or, as in the case of the examples shown here, synthesized by software, and this array is then tested for a match with the cycles of range of reference frequencies, one frequency at a time.

The method used to determine the degree of match can be illustrated by considering a very simple case of testing for the match between one cycle of a sine wave held in the array and one cycle of reference frequency, where we know that we should obtain a maximum match.

The array is divided into two equal parts, the first part representing 0° to 180° (the half-cycle with positive values) and the second part 180° to 360°, the negative half-cycle. The elements of the 0° to 180° section are then summed and this result is added to the result of summing and inverting the sign of the 180° to 360° section. Thus we obtain a grand total of positive sign which represents a perfect match for that sine wave of that amplitude.

This, however, is true only for a sine wave. If the array held one cycle of a cosine wave, the above procedure would result in a total of zero. Therefore the procedure has to be repeated with the difference that the array is divided at the points equivalent to 90° and 270°, with the first summing taking place from 0° to 90° and 270° to 360°, and the second, with the sign inverted, between 90° and 270°. The grand total is then as for the sine wave. To take care of all phase angles the square root of the sum of the squares of the two grand results is taken.

Thus, in testing for a match with one cycle as the reference frequency, the array has been divided into four parts with sign changes at appropriate points. To test for a match with two cycles, the array is divided into eight parts, and so on for greater numbers of cycles.

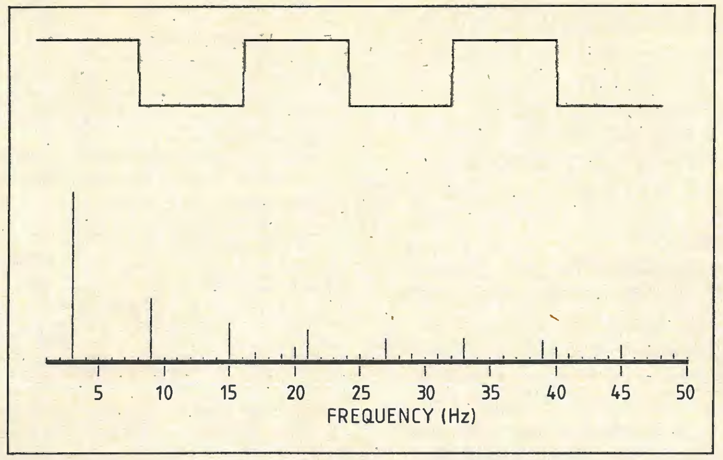
At this point I considered the problem solved, but a few test runs showed an error which appeared for integer sub-harmonics of odd-order reference cycles, arising from assymmetry in the summing procedures. A few extra lines of software corrects for the error, although it does dictate that the analysis must run from the higher frequencies to the lower to save duplicating some of the calculating.

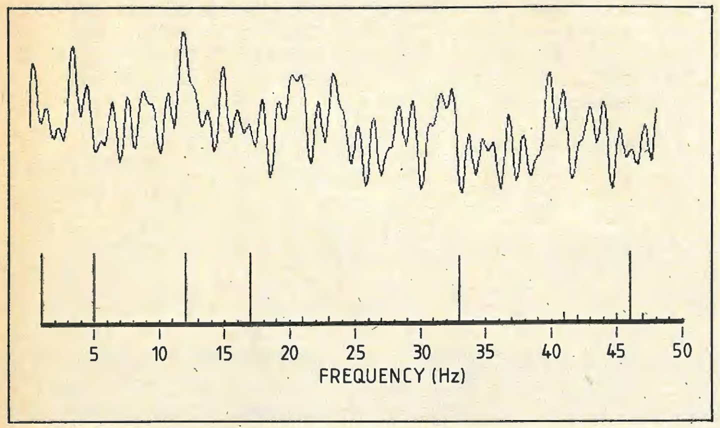
The first example given shows the analysis of a waveform synthesized from equal amplitudes of 1, 5, 12, 17, 33 and 46 cycles, all of which have been resolved satisfactorily by the program. The second example is for three cycles of square wave, where the expected harmonic pattern is shown by the analysis. There are some small spurious results, which I believe arise from rounding problems in the program.

The listing shows the simplicity of the programs. In line 20 the number of array points required is chosen for D%, 500 in this case. Likewise, the maximum number of cycles for the reference frequency is chosen for F% and is 50 here. The only limits for these figures are available memory, run time for the program and resolution or aliasing problems. Lines 60 to 110 synthesize and draw the waveform. The remainder perform the calculations and draw the result as the program runs. Line 160 determines the division factor for the array and line 190 organizes the required sign changes. The summing occurs in the loop at 200, and the error correction in lines 270 to 310. I am sure that considerable polishing can be done to the program and perhaps some kind reader can turn it into machine code!

R B Hale
St Albans
Hertfordshire

```
 10 REM "FREQUENCY ANALYSIS" R.B.HALE
 20 D%=500:F%=50
 30 DIM A%(D%),R%(F%),S%(F%)
 40 CLS:MODE0
 50 PRINT"       Sample Waveform"
 60 S=2*PI/D%
 70 MOVE INT(1200/D%),900
 80 FOR Y%=1 TO D%:T=S*Y%
 90 A%(Y%)=SIN(T)*400+SIN(T*5)*400+COS(T*12)*400
      +SIN(T*17)*400+SIN(T*33)*400+SIN(T*46)*400
100 DRAW INT(Y%*1200/D%),A%(Y%)/10+900
110 NEXT
120
130 VDU5
140 MOVE 100,30:PRINT"Frequency Analysis"
150 FORV%=F% TO 1 STEP-1
160 M=D%/(V%*4):N%=1:J%=0:K%=0
170 REPEAT
180 L%=0:Z%=N%*M
190 IF N%MOD2=0 K%=-K% ELSE J%=-J%
200 FOR Y%=((N%-1)*M)+1 TO Z%
210 L%=L%+A%(Y%)
220 NEXT
230 J%=J%+L%:K%=K%+L%:N%=N%+1
240 UNTIL Y%>D%-1
250 Z=SQR(J%*J%+K%*K%)*.625/D%
260 R%(V%)=Z:C=0
270 FOR A%=3 TO F%-1 STEP 2
280 IF V%*A%>F% L%=0 ELSE L%=A%
290 C=C+S%(V%*L%)/A%
300 NEXT
310 S%(V%)=Z-C:P=(V%*1250/F%)
320
330 MOVE P,120
340 DRAW P,Z-C+120
350 F=INT((V%+.01)*10)/10
360 IF F MOD 5=0 MOVE P,100:DRAW P,80:
    MOVE P-145,70:PRINT INT(V%+.01)
370 NEXT
380 VDU4
```





FUNDAMENTALS OF ENERGY TRANSFER

May I offer a few thoughts on that part of Chris Parton's letter (*E&WW*, Dec, 1984, p.66) relating to the NPL definition of the ampere involving infinitely long parallel conductors? It seems to me that electric current is defined simply by the differential equation.

$$i=dq/dt \qquad (1)$$

When the unit of charge is the coulomb (a physical quantity) and the unit of time is the second (a physical quantity) we obtain the unit of current called the ampere (a mathematical concept).

The NPL definition of the ampere seems at first sight to involve forethoughts that the ampere has to be subsequently realised by a physical system because of its practical utility and that the definition is "superior" to the c.g.s. "circle of wire" definition. When we try to define it apart from Eq (1) we always run into difficulties over concepts such as "conductors of infinite length" and so on which are not allowed in real life physical systems. The c.g.s. "circle of wire" definition also involves difficulties: does a unit pole exist? How does the current enter and leave the coil? What is meant by force? etc.

What the NPL is doing is defining the ampere in an "absolute type" of way. The term "absolute" was introduced by Gauss, meaning independent of the size of any particular instrument, or the value of gravity at any particular instrument, or the value of gravity at any particular place, or of any other arbitrary quantities than the three standards of length, mass and time. But with concepts such as electric current I do not see how the difficulties I have mentioned can be avoided. Mechanical quantities can be defined in Gauss's absolute way but it is better, I think, to refer to "the NPL definition of the ampere" and to realise that it is an "absolute type" of concept from which any practicality has been removed. When the NPL has to realise the ampere practically then, of course, all thoughts of infinite conductors, unit poles, etc. vanish from their minds and they turn to the realities of forces and torques on mutually magnetically coupled coils, masses and levers.

May I draw readers' attention to part of a comment by Dr A. T. Starr (whom I knew at Callender's Research Laboratories in 1939 and for whom I have the utmost respect)? "The development of electromagnetism adopted in this chapter is regarded with disfavour by many teachers of the subject and international committees. A few words in defence of the method will therefore be given . . . we are told that the idea of a magnetic pole is very deluding and that we are likely to find ourselves 'floundering in a world of make-believe'. This need not alarm us, as anything abstract is 'make-believe' and may be indulged in, provided it is self-consistent and useful . . . the fact that a North Pole is associated with an equal South Pole is not sufficient to make the idea of a single pole useless or misleading, just as the fact that every reaction does not prevent the idea of force from being useful." The whole of this reference is very worthwhile reading.

In conclusion, I feel that the 'wisdom of our forefathers' was in the c.g.s. definition and that the NPL has erred in adopting the infinitely long wire definition. Chris Parton is to be congratulated on explaining the absurdity of introducing infinity into any 'absolute type' of definition. May I gently remind him, however, that parallel infinite wires never occurred originally in any c.g.s. definition?

Philip John Drake
Whickham
Newcastle-on-Tyne

Reference

1. A.T. Starr, Electric circuits and wave filters. Pitman. 2nd ed., 1944, pp.63-65.

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26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No of Ways	9	15	25	37
MALE:				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	—
FEMALE:				
St Pin	100	140	210	380
Ang Pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	—
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2 × 36-way	250p	—
1 × 43-way	260p	—
2 × 22-way	190p	—
2 × 43-way	395p	—
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24" Single end Male	£5.00
24" Single end Female	£5.25
24" Female Female	£10.00
24" Male Male	£9.50
24" Male Female	£9.50

DIL SWITCHES

4-way	90p	6-way	105p
8-way	120p	10-way	150p

RIBBON CABLE

(grey/metre)

10-way	40p	34-way	160p
16-way	60p	40-way	180p
20-way	85p	50-way	200p
26-way	120p	64-way	280p

DIL HEADERS

	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
18 pin	60p	—
20 pin	75p	—
24 pin	100p	150p
28 pin	160p	200p
40 pin	200p	225p

ATTENTION

All prices in this double page advertisment are subject to change without notice.
ALL PRICES EXCLUDE VAT
Please add carriage 50p unless indicated as follows: (a) £8 (b) £2.50 (c) £1.50 (d) £1.00

TECHNOLINE VIEWDATA SYSTEM. TEL: 01-450 9764

Using 'Prestel' type protocols. For information and orders — 24 hour service, 7 days a week

74 SERIES

7400	0.30
7401	0.30
7402	0.30
7403	0.30
7404	0.36
7405	0.30
7406	0.40
7407	0.40
7408	0.30
7409	0.30
7410	0.30
7411	0.30
7412	0.30
7413	0.50
7414	0.70
7416	0.36
7417	0.40
7420	0.30
7421	0.60
7422	0.36
7423	0.36
7425	0.40
7426	0.40
7427	0.32
7428	0.43
7430	0.30
7432	0.36
7433	0.30
7437	0.30
7438	0.40
7439	0.40
7440	0.40
7441	0.90
7442A	0.70
7443A	1.00
7444	1.10
7445	1.00
7446A	1.00
7447A	1.00
7448	1.00
7450	0.36
7451	0.35
7453	0.38
7454	0.38
7460	0.55
7470	0.50
7472	0.45
7473	0.45
7474	0.50
7475	0.60
7476	0.45
7480	0.65
7481	1.80
7483A	1.05
7484A	1.25
7485	1.10
7486	0.42
7489	2.10
7490A	0.55
7491	0.70
7492A	0.70
7493A	0.55
7494	1.10
7495A	0.60
7496	0.80
7497	2.10
74100	1.90
74107	0.50
74109	0.75
74110	0.75
74111	0.55
74116	1.70
74118	1.10
74119	1.70
74120	1.00
74121	0.55
74122	0.70
74123	0.80
74125	0.65
74126	0.55
74128	0.55
74132	0.75
74136	0.70
74141	0.90
74142	2.50
74143	1.30
74144	2.70
74145	1.10
74147	1.70
74148	1.40
74150	1.75
74151A	0.70
74153	0.80
74154	1.40
74155	0.80
74156	0.90
74157	0.80
74159	1.75
74160	1.10
74161	0.80
74162	1.10
74163	1.10
74164	1.20
74165	1.10
74166	1.40
74167	4.00
74170	2.00
74172	4.20
74173	1.40
74174	1.10
74175	1.05
74176	1.00
74178	1.50
74179	1.50
74180	1.00
74181	3.40
74182	1.40
74184	1.80
74185A	1.80
74190	1.30
74191	1.30
74192	1.10
74193	1.15
74194	1.10
74195	0.80
74196	1.30
74197	1.10
74198	2.20
74199	2.20
74221	1.10
74251	1.00
74259	1.50
74265	0.80
74273	2.00
74276	1.40
74278	1.70
74279	0.90
74283	1.05
74742	3.20
74290	0.90
74293	0.90
74298	1.80
74351	2.00
74365A	0.80
74366A	0.80
74367A	0.80
74376	1.60
74390	1.10
74393	1.20
74490	1.40

74LS SERIES

74LS00	0.24
74LS01	0.24
74LS02	0.24
74LS03	0.24
74LS04	0.24
74LS05	0.24
74LS08	0.24
74LS09	0.24
74LS10	0.24
74LS11	0.24
74LS13	0.34
74LS14	0.50
74LS15	0.24
74LS20	0.24
74LS21	0.24
74LS22	0.24
74LS24	0.50
74LS26	0.26
74LS27	0.24
74LS28	0.24
74LS30	0.24
74LS32	0.24
74LS32	0.24
74LS33	0.24
74LS37	0.24
74LS38	0.24
74LS40	0.24
74LS42	0.50
74LS43	1.50
74LS48	0.90
74LS49	1.00
74LS51	0.24
74LS54	0.24
74LS55	0.24
74LS73A	0.30
74LS74A	0.35
74LS75	0.45
74LS76A	0.36
74LS78	0.42
74LS83A	0.70
74LS85	0.75
74LS86	0.35
74LS90	0.48
74LS91	0.90
74LS92	0.35
74LS93	0.54
74LS95B	0.75
74LS96	0.90
74LS107	0.40
74LS109	0.40
74LS112	0.45
74LS113	0.45
74LS114	0.45
74LS122	0.70
74LS123	o.80
74LS125	0.50
74LS126	0.50
74LS132	0.65
74LS133	0.55
74LS136	0.45
74LS138	0.55
74LS139	0.55
74LS145	0.95
74LS147	1.75
74LS148	1.40
74LS151	0.65
74LS152	2.00
74LS153	0.65
74LS154	1.60
74LS155	0.65
74LS156	0.65
74LS157	0.50
74LS158	0.65
74LS160A	0.65
74LS161A	0.75
74LS162A	0.75
74LS163A	0.75
74LS164	0.75
74LS165A	1.10
74LS166A	1.50
74LS168	1.30
74LS169	1.00
74LS170	1.40
74LS173A	1.00
74LS174	0.75
74LS175	0.75
74LS181	2.00
74LS183	1.90
74LS190	0.75
74LS191	0.75
74LS192	0.80
74LS194A	0.75
74LS195A	0.75
74LS196	0.80
74LS197	0.80
74LS221	0.90
74LS240	0.80
74LS241	0.80
74LS242	0.90
74LS243	0.90
74LS244	0.80
74LS245	1.10
74LS247	1.10
74LS248	1.10
74LS249	1.10
74LS251	0.75
74LS253	0.75
74LS256	0.90
74LS2457A	0.70
74LS258A	0.70
74LS259	1.20
74LS260	0.75
74LS266	0.60
74LS273	1.25
74LS279	0.70
74LS280	1.90
74LS283	0.80
74LS290	0.80
74LS292	9.00
74LS293	0.80
74LS295	1.40
74LS297	9.00
74LS298	1.00
74LS299	2.20
74LS321	3.70
74LS322A	3.90
74LS323	3.00
74LS324	3.20
74LS348	2.00
74LS352	1.20
74LS353	1.20
74LS356	2.10
74LS363	1.80
74LS364	1.80
74LS365	0.50
74LS366	0.50
74LS367	0.52
74LS368	0.50
74LS373	0.90
74LS374	0.90
74LS375	0.75
74LS377	1.30
74LS378	0.95
74LS379	1.30
74LS381	4.50
74LS385	3.25
74LS390	0.60
74LS393	1.00
74LS395A	1.00
74LS399	1.40
74LS445	1.80
74LS465	1.20
74LS467	1.20
74LS490	1.50
74LS540	1.00
74LS541	1.00
74LS608	7.00
74LS610	19.00
74LS612	19.00
74LS624	3.50
74LS626	2.25
74LS628	2.25
74LS629	1.25
74LS640	2.00
74LS640-1	3.00
74LS641	1.50
74LS642	2.50
74LS642-1	3.00
74LS643	2.50
74LS643-1	3.00
74LS644	3.50
74LS645	2.00
74LS645-1	4.00
74LS668	0.90
74LS669	0.90
74LS670	1.70
74LS682	2.50
74LS683	3.00
74LS684	3.50
74LS687	3.50
74LS688	3.50
74LS783	21.00

74S SERIES

74S00	0.50
74S02	0.50
74S04	0.50
74S05	0.50
74S08	0.50
74S10	0.50
74S11	0.75
74S20	0.50
74S22	0.50
74S30	0.50
74S32	0.60
74S37	0.60
74S38	0.60
74S40	0.50
74S51	0.60
74S64	0.45
74S74	0.70
74S85	3.00
74S86	1.00
74S112	1.50
74S113	1.20
74S114	1.20
74S124	3.00
74S132	1.00
74S133	0.60
74S138	1.80
74S139	1.80
74S140	1.00
74S151	1.50
74S153	1.50
74S157	2.00
74S158	2.00
74S163	3.00
74S169	5.50
74S174	3.00
74S175	3.20
74S188	1.80
74S189	1.80
74S194	3.00
74S195	3.00
74S196	3.50
74S200	4.50
74S201	3.20
74S225	5.20
74S240	4.00
74S241	4.00
74S244	4.50
74S251	2.50
74S257	2.50
74S258	2.50
74S260	1.00
74S261	3.00
74S283	2.70
74S287	2.25
74S288	2.00
74S289	2.25
74S299	4.50
74S373	4.00
74S374	4.00
74S387	2.25

74C SERIES

74C00	0.70
74C04	0.50/ 4069
74C08	0.70
74C10	0.70
74C14	0.50/ 4016 4584
74C20	0.70
74C32	1.00
74C42	1.50
74C48	1.50
74C73	1.00
74C74	1.20
74C76	1.00
74C83	2.00
74C85	2.25
74C86	0.50
74C90	1.90
74C93	1.50
74C95	1.60
74C107	1.00
74C150	5.00
74C151	2.00
74C157	2.50
74C160	1.80
74C161	1.80
74C162	1.80
74C163	1.80
74C173	1.00
74C174	1.50
74C175	1.50
74C193	1.50
74C194	1.50
74C195	1.50
74C221	2.50
74C244	2.00
74C245	2.25
74C373	2.25
74C374	2.25
74C902	1.20
74C911	9.00
74C912	4.50
74C922	6.00
74C923	6.50
74C925	6.50
74C926	7.50

74ALS SERIES

74ALS00	0.45
74ALS02	0.45
74ALS04	0.50
74ALS08	0.50
74ALS10	0.45
74ALS20	0.45
74ALS32	0.45
74ALS74	0.70
74ALS138	1.50
74ALS139	1.50
74ALS244	4.00
74ALS245	4.75
74ALS573	2.60
74ALS574	4.50
74ALS580	2.60

4000 SERIES

4000	0.20
4001	0.24
4002	0.25
4006	0.70
4007	0.25
4008	0.60
4009	0,45
4010	0.60
4011	0.24
4012	0.25
4013	0.36
4014	0.60
4015	0.70
4016	0.36
4017	0.55
4018	0.60
4019	0.60
4020	0.80
4021	0.60
4022	0.70
4023	0.30
4024	0.48
4025	0.24
4026	0.90
4027	0.40
4028	0.60
4029	0.75
4030	0.35
4031	1.25
4032	1.00
4033	1.25
4034	2.50
4035	0.70
4036	2.50
4037	1.10
4038	1.00
4040	0.60
4041	0.55
4042	0.50
4043	0.60
4044	0.60
4045	1.00
4046	0.60
4047	0.60
4048	0.55
4049	0.36
4050	0.35
4051	0.65
4052	0.60
4053	0.60
4054	0.80
4055	0.80
4056	0.85
4060	0.70
4063	0.85
4066	0.40
4067	2.30
4068	0.25
4069	0.24
4070	0.24
4071	0.24
4072	0.24
4073	0.24
4075	0.24
4076	0.65
4077	0.25
4078	0.25
4081	0.24
4082	0.25
4085	0.60
4086	0.75
4089	1.20
4093	0.35
4094	0.90
4095	0.95
4096	0.90
4097	2.70
4098	0.75
4099	0.99
4501	0.36
4502	0.55
4503	0.36
4504	0.95
4505	3.60
4506	0.90
4507	0.35
4508	1.20
4510	0.55
4511	0.55
4512	0.55
4513	1.50
4514	1.10
4515	1.10
4516	0.55
4517	2.20
4518	0.48
4519	0.32
4520	0.60
4521	1.15
4522	0.80
4526	0.70
4527	0.80
4528	0.65
4529	1.00
4531	0.75
4532	0.65
4534	3.80
4536	2.50
4538	0.75
4539	0.75
4541	0.90
4543	0.70
4551	1.00
4553	2.40
4555	0.36
4556	0.50
4557	2.40
4560	1.40
4566	1.40
4568	2.40
4569	1.70
4572	0.45
4583	0.90
4584	0.48
4585	0.60
4724	1.50
14411	7.50
14412	7.50
14416	3.00
14419	2.60
14490	4.20
14495	4.50
145000	6.50
14599	2.00
22100	3.50
22101	7.00
22102	7.00
40014	0.48
40085	1.20
40097	0.36
40098	0.40
40100	1.50
40101	1.25
40102	1.30
40103	2.00
40104	1.20
40105	1.50
40106	0.48
40107	0.55
40108	3.20
40109	0.80
40110	2.25
40114	2.25
40147	2.80
40163	1.00
40173	1.20
40174	1.00
40175	1.00
40192	1.00
40193	1.00
40194	1.00
40244	1.50
40245	1.50
40257	1.80
40373	1.80
40374	1.80
80C95	0.75
80C97	0.75
80C98	0.75

LINEAR ICs

AD7581	12.00
ADC0808	11.90
AM7910DC	25.00
AN-1-5050	1.00
AY-3-1350	3.50
AY-3-8910	4.90
AY-3-8912	5.00
CA3019A	1.00
CA3020	3.50
CA3028A	1.10
CA3046	0.70
CA3059	3.25
CA3060	3.50
CA3080E	0.70
CA3085	1.50
CA3086	0.60
CA3089E	2.50
CA3090AQ	3.75
CA3130E	0.90
CA3130T	1.30
CA3140E	0.45
CA3140T	1.00
CA3146	2.25
CA3160E	1.50
CA3161E	2.00
CA3162E	6.00
CA3189E	2.70
CA3240E	1.50
CA3280G	3.00
D7002	6.00
DAC1408-8	3.00
DAC0800	3.00
DAC0808	3.00
DG308	3.00
HA1366	1.90
ICL7106	6.75
ICL7611	0.95
ICL7650	4.00
ICL7660	2.50
ICL8038	4.00
ICM7216B	22.00
ICM7217	7.50
ICM7555	0.90
ICM7556	1.40
LC7120	3.00
LC7130	3.00
LC7131	3.50
LC7137	3.50
LF347	1.20
LF351	0.60
LF353	0.90
LF355	0.90
LF356N	1.10
LF357	1.00
LF398	4.00
LM10CLH	4.50
LM301A	0.30
LM307	0.45
LM308CN	0.75
LM310	2.25
LM311	0.60
LM318	1.50
LM319	1.80
LM324	0.45
LM334Z	1.15
LM335Z	1.30
LM336	1.60
LM339	0.40
LM348	0.60
LM358P	0.50
LM377	3.00
LM380N-8	1.50
LM380N	1.50
LM381AN	1.70
LM383	3.25
LM384	2.20
LM386N-1	1.00
LM387	2.70
LM389	1.89
LM391	1.80
LM392N	1.10
LM393	0.85
LM394CH	4.00
LM709	0.35
LM710	0.48
LM711	1.00
LM723	0.60
LM725CN	3.00
LM733	0.65
LM741	0.22
LM7747	0.70
LM748	0.30
LM1011	4.80
LM1014	1.50
LM1801	3.00
LM1830	2.50
LM1871	3.00
LM1872	3.00
LM1886	6.00
LM1889	4.50
LM2917	3.00
LM3302	0.90
LM3900	0.80
LM3909	1.00
LM3911	1.80
LM3914	3.50
LM3915	3.40
LM3916	3.40
LM13600	1.50
M51513L	2.30
M51516L	4.50
MB3712	2.00
MC1310P	1.50
1413	0.75
MC1458	0.45
MC1495	3.00
MC1496	0.70
MC3340P	2.00
MC3401	0.70
MC3403	0.65
MF10CN	4.10
MK50240	9.00
MK50398	11.00
ML902	5.00
ML922	4.00
MM6221A	3.00
NE529	2.20
NE531	1.20
NE544	1.90
NE555	0.22
NE556	0.60
NE564	4.00
NE565	1.20
NE566	1.50
NE567	1.25
NE570	4.00
NE571	3.00
NE592	0.90
NE5532P	1.50
NE5533P	1.60
NE5534P	1.20
NE5534AP	1.50
OP-07EP	3.50
PLL02A	5.00
RC4136	0.55
RC4151	2.00
RC4195	1.50
RC4558	0.55
S566B	2.20
S50240	9.00
SAA1900	16.00
SFF96364	8.00
SL490	3.00
SN76013N	3.00
SN76023N	3.00
SN76033N	3.00
SN76115N	2.15
SN76489	4.00
SN76495	4.00
SN76660	1.20
SPO256AL2	7.00
SP8515	7.50
TA7120	1.20
TA7130	1.40
TA7204	1.50
TA7205	0.90
TA7222	1.50
TA7310	1.50
TBA641BX1	4.00
TBA231	1.20
TBA800	0.80
TBA810	0.90
TBA20	0.80
TBA820M	0.75
TBA920	2.00
TBA950	2.25
TC9109	5.00
TCA210	3.50
TCA220	3.50
TCA270	3.50
TCA940	1.75
TDA1004A	5.00
TDA1010	2.25
TDA1022	4.50
TDA1024	1.10
TDA1170S	3.00
TDA2002	3.25
TDA2003	1.90
TDA2004	2.40
TDA2006	3.20
TDA2020	3.20
TDA2030	2.50
TDA2593	5.00
TDA2653	7.00
TDA3560	7.50
TDA3810	7.50
TDA7000	3.50
TEA1002	7.00
TL061CP	0.40
TL062	0.60
TL064	0.90
TL071	0.40
TL072	0.70
TL074	1.10
TL081	0.35
TL082	0.55
TL083	0.75
TL084	1.00
TL094	2.00
TL170	0.50
TL430C	1.20
UAA1003-3	9.35
UA759	3.20
UA2240	1.20
UAA170	1.70
UCN4801A	4.00
ULN2001A	0.75
ULN2002A	0.75
ULN2003A	0.75
ULN2004A	0.75
ULN2068	2.90
ULN2802	1.90
ULN2803	1.80
ULN2804	1.90
UPC575	2.75
UPC592H	2.00
UPC1156H	3.00
UPC1185H	5.00
XR210	4.00
XR2206	4,50
XR2207	3.75
XR2211	5.75
XR2216	6.75
XR2240	1.20
ZN404	1.00
ZN414	0.80
ZN419P	1.75
ZN423E	1.30
ZN424E	1.30
ZN425E8	3.50
ZN426E8	3.00
ZN427E8	6.00
ZN428E8	4.50
ZN429E8	2.25
ZN447E	9.00
ZN449E	3.00
ZN450E	7.50
ZN459CP	3.00
ZN1034E	2.00
ZNA1040	6.60
ZNA134J	23.00
ZNA234E	9.50

VOLTAGE REGULATORS

1A FIXED VOLTAGE PLASTIC TO220

+VE		−VE	
5V 7805	0.45	7905	0.50
6V 7806	0.50	7906	0.50
6V 7808	0.50	7908	0.50
12V 7812	0.45	7912	0.50
15V 7815	0.50	7915	0.15
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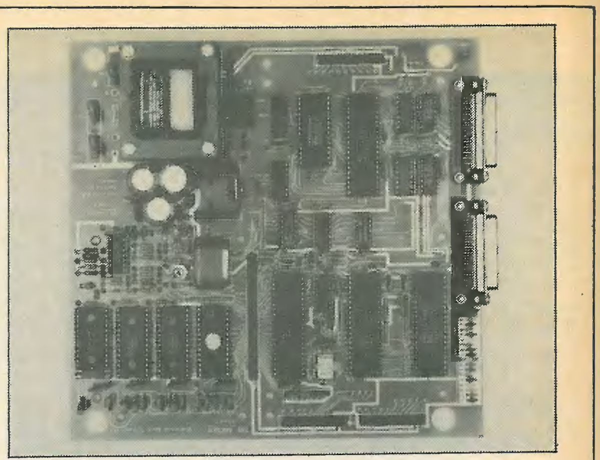

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CIRCLE 136 FOR FURTHER DETAILS.

Digital filters explained

by H.J. Hutchings, B.A.

H.J. Hutchings is currently lecturer in electronics and control in the School of Engineering, Humberside College of Higher Education. A graduate of the Open University, he worked as an instrumentation technician with Hawker Siddeley (Aviation) Ltd before entering technical education in 1973 as an assistant lecturer at the Grimsby College of Technology. He is also a part-time tutor with the Open University.

The daunting mathematics commonly associated with descriptions of sampled data systems has been largely avoided in this geometrical interpretation of a first-order low-pass filter.

The rapid growth of microelectronics and home computers has meant that the characteristics of low-pass, band-pass and high-pass filters can be readily implemnented in software form. This article describes the behaviour of a simple low-pass digital filter in terms of convolution, impulse response, amplitude and phase response, using only elementary mathematics.

Digital filters have numerous attractions. Weight, size, cost and flexibility favour the digital filter. The response of a digital filter is independent of component tolerances, does not require alignment and is immune to temperature variations. Simply modifying the program changes filter characteristics. And it is possible to achieve results that are impractical using the analogue counterpart.

The implementation

The diagram of Fig. 1 shows how an analogue-to-digital converter, computer and digital-to-analogue converter may be connected to achieve the necessary signal processing for digital filtering. The filter is implemented by an alogirthm within the computer which *convolutes* the sampled sequence x(n) with the impulse response sequence of the filter h(n) to provide the output sequence y(n). Convolution is the name given to the ordered combination of multiplication and summation. The mathematical shorthand is deceptively simple:

$$y(n)=h(n)\ast x(n) \tag{1}$$

where $\ast$ indicates the operation of convolution.

This terse symbolism represents a powerful mathematical technique applicable to both analogue and digital systems. Fortunately the sampled data version of convolution requires little prior knowledge and an adequate toolkit is the ability to draw and understand a graph, to multiply in an ordered manner and finally to add the products. I now show a little of the physical reality which lies behind the abstraction of equation 1.

The analogue signal presented to the a-d converter will be converted into a series of discrete samples; how many samples or snapshots must be taken to describe the signal completely? To avoid aliasing it is necessary to sample at a rate which is at least twice the highest frequency present — the Nyquist frequency. The Fourier spectrum of the signal, together with the sampling frequency illustrates the point — Fig. 2.

The recipe

Suppose the sampled signal can be represented by the sequence of pulses x_0, x_1, x_2, x_3, x_4, each of which is separated from its neighbour by the fixed interval T, the signal processing time. Each sample pulse in turn will stimulate the filter, which responds with a train of weighted output pulses. If the memory of the filter is long enough, there will still be a vestige of the previous history of weighted outputs, even as the current pulse is being processed, wnich as you might expect complicates matters. An input sequence together with a possible impulse response is shown in Fig. 3. Both series of pulses are assumed to start at time $t=0$.

To evaluate y_n, the output of the system after n conversions, a systematic approach is required. In the Table the rows represent the response to the input sequence x_0, x_1, x_2, x_3, x_4 respectively.

$t=0$	$t=T$	$t=2T$	$t=3T$	$t=4T$
x_0h_0	x_0h_1	x_0h_2	x_0h_3	x_0h_4
	x_1h_0	x_1h_1	x_1h_2	x_1h_3
		x_2h_0	x_2h_1	x_2h_2
			x_3h_0	x_3h_1
				x_4h_0

The columns show the terms present at times $t=0$, $t=T$, $t=2T$ etc. The response y_n is simply the sum of the terms in the nth column. The sums of the five columns are

$$y_0=x_0h_0$$
$$y_1=x_0h_1+x_1h_0$$
$$y_2=x_0h_2+x_1h_1+x_2h_0$$
$$y_3=x_0h_3+x_1h_2+x_2h_1+x_3h_0$$
$$y_4=x_0h_4+x_1h_3+x_2h_2+x_3h+x_4h_0.$$

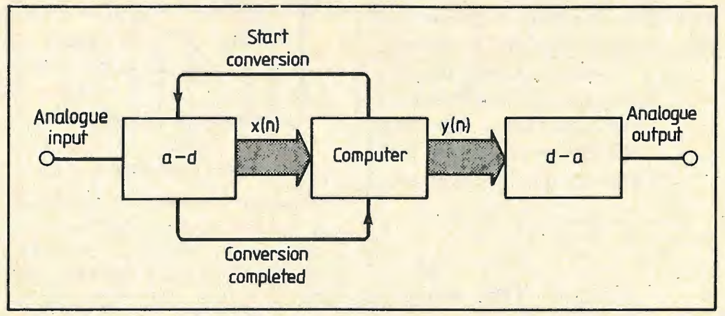


Fig. 1. The a-d converter is synchronized with the program by control signals to enable the complete signal processing time (T) to be fixed.

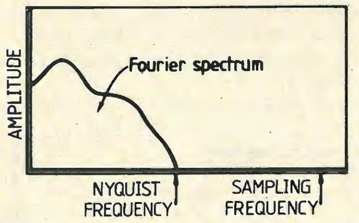


Fig. 2. Shannon's sampling theorem in action. To avoid signal corruption due to aliasing the sampling frequency f = 1/T should be set at least twice the Nyquist frequency.

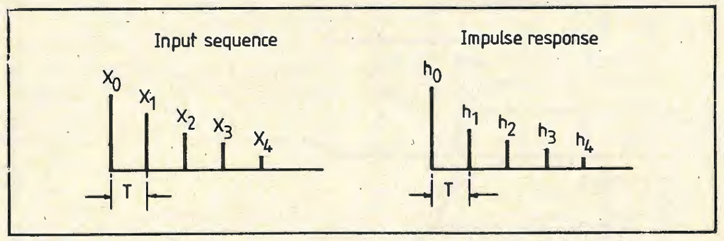


Fig. 3. Sampled input signal is represented as a sequence of pulses each separated by the fixed interval T. The behaviour of the linear processor is characterised by the impulse response sequence.

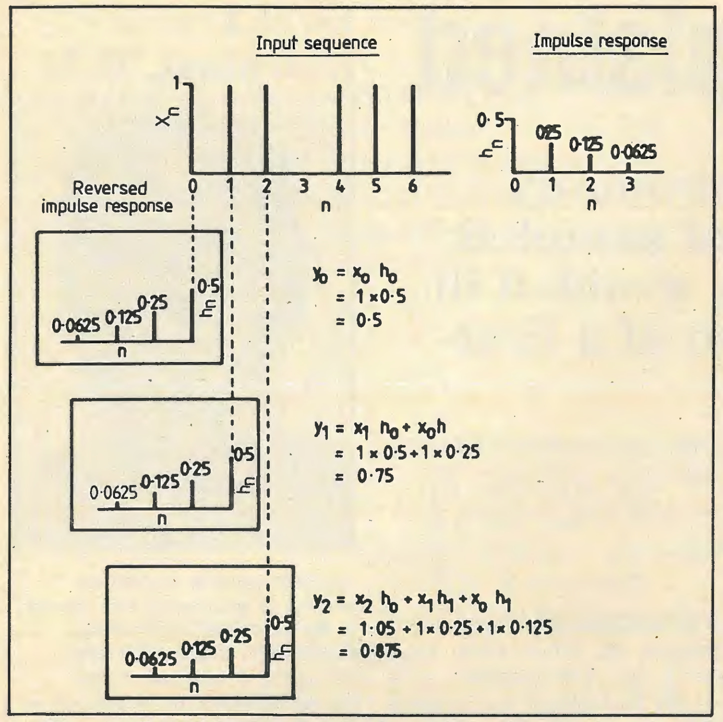


Fig. 4. Graphical convolution of the input signal and impulse response is achieved by reversing the impulse response under the sample of current interest. Sum of the coincident cross products is the convolution of

Fig. 5. Effect of signal processing has been to remove certain high-order harmonics and to produce some time delay. Remaining harmonics sum at the output to produce the familiar exponential response.

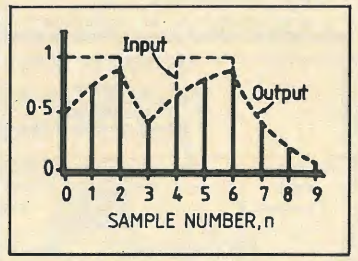


Fig. 6. This simple first-order low-pass analogue filter has time constant $\tau = CR$ seconds. Magnitude and phase response show that low frequencies are processed with negligible amplitude and phase modification.

Within this algebraic jungle there exists a very simple pattern. To find the convoluted response, simply reverse the impulse response, aligning it so that h_0 and the sample of current interest x_n are coincident; the ordered weight products will then follow automatically. A numerical example may help, Fig. 4.

Table 1

Sample n	Current input x_n	Previous output y_{n-1}	Current output y_n
0	1	0	½
1	0	½	2
2	0	¼	⅛
3	0	¼	1/16
4	0	1/16	1/32
5	0	1/32	1/64
etc.			

To find the rest of the terms in the sequence in Fig. 4, continue moving the reversed impulse response to the right until none of the samples of the two sequences overlap. My results,

$y_3 = 0.4375$ $y_4 = 0.6875$
$y_5 = 0.8125$ $y_6 = 0.875$
$y_7 = 0.4375$ $y_8 = 0.1875$
$y_9 = 0.0625$

are plotted in Fig. 5. The exponential nature of the output waveform suggests the digital signal processing is similar to that provided by a simple low-pass analogue filter. Fig. 6 shows the type of circuit together with the expected frequency and phase response.

If you have time, investigage the effect of the digital filter on the sampled sequences shown in Fig. 7.

I hope you found the effect of processing the unit sample is simply the impulse response of the filter h_n. The impulse response characterizes the behaviour of the filter. Convolution in the time domain corresponds to multiplication in the frequency domain, which is equivalent to multiplying the signal frequency spectrum by the system frequency response, the product corresponding to a filtering operation.

The program

To implement this particular filter in software form, consider the recurrence relationship

$$y_n = 0.5x_n + 0.5y_{n-1} \qquad (2)$$

where x_n is the current input sample, y_n the current output and y_{n-1} the previous output. Let's apply unit input sample $x_0 = 1$ and see what happens. Assume that the previous output y_{n-1} is zero prior to this event; intuitively, this is reasonable since the effect cannot preceed the cause.

Again a systematic approach is advisable, the notation used in Table 1 where the current output becomes the previous output one sample later is a useful way of keeping track of the calculation.

This type of filter is said to have an infinite impulse response; compare with the impulse response shown in Fig. 4, in which the response was deliberately truncated after the first four terms for ease of calculation.

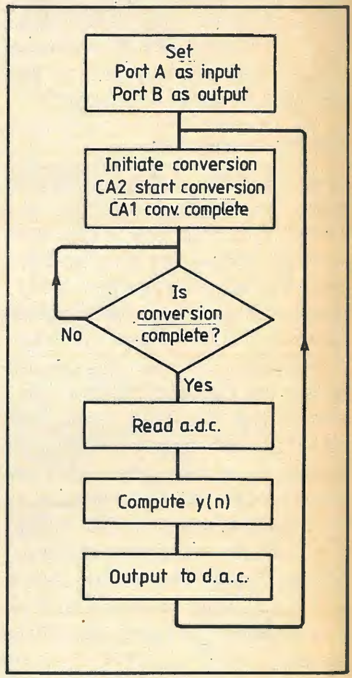
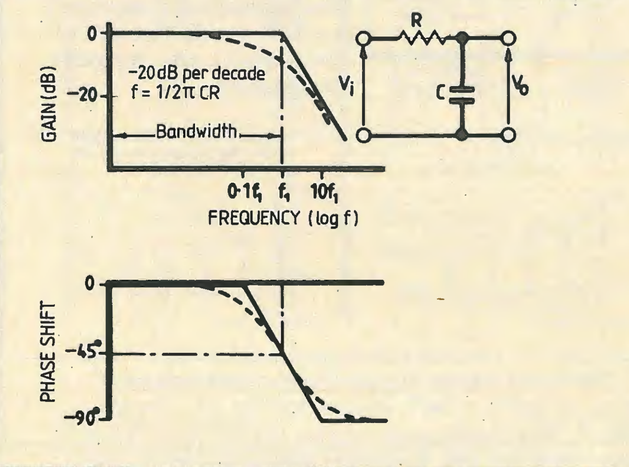


Fig. 8. Demonstration program samples audio input, computes $y(n) = 0.5x(n) + 0.5y(n-1)$ and outputs binary value.



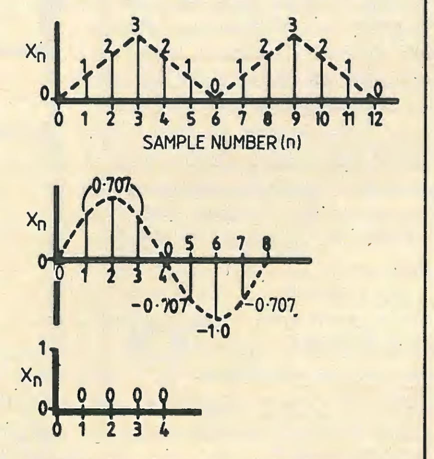


Fig. 7, left. Example waveforms, see text.

A computer performs calculations such as these with ease, see Fig. 8. If the speed of operation is not critical a Basic program would be suitable but for real-time programming of audio signals Basic is far too slow and machine language is the best choice.

Assembler 6502

```
        LDA #00
        STA A003
        LDA #FF
        STA A002
START:  LDA #0E
        STA A 00C
        LDA #0C
        STA A00C
        LDA #0E
        STA A00C
LABEL:  LDA A00D
        AND #02
        BEQ LABEL
        LDA A001
        LSR A
        ADC TEMP
        STA TEMP
        STA A000
        LSR A
        STA TEMP
        JUMP START
```

AIM Basic

```
10      POKE 40963, 0
20      POKE 40962,255
30      POKE 40972,14
40      POKE 40972,12
50      POKE 40972,14
60      P=PEEK (40972)
70      IF P AND 2 THEN 90
80      GOTO60
90      X=PEEK (40961)
100     X=X*0.5
110     Y=X+Z
120     POKE 40950, Y
130     Z=Y*0.5
140     GOTO 30
```

Frequency response and the operator z

Anyone who has presevered so far must be wondering when we are going to explore the familiar themes of cut-off frequency and bandwidth in relation to a digital filter. As the Nyquist frequency is half the sampling frequency any gain-frequency reponse plot must be expressed in terms of this. The precise shape of the filter response can be readily deduced from the positions of the poles and zeros plotted in the z-plane. Unfortunately I cannot justify this statement without exposing you to a panorama of some relatively advanced mathematical concepts, which is not my intention. However, if you are prepared to accept this in good faith, then what follows will provide a reasonable insight into the frequency response of digital filters together with a pictorial explanation of aliasing.

The recurrence relationship obtained for y_n involved taking a sample, weighting it, and then adding it to the previous weighted output, delayed by one sampling period. In an effort to make the recurrence relationship a little more attractive I use the notation

$$y(n) = \frac{x(h)}{2} + \frac{y(n-1)}{2}, \qquad (3)$$

which means exactly the same as equation 2. This can be transformed into an expression in z by writing

$y(n) = y(z)$,
$x(n) = x(z)$ and
$y(n-1) = z^{-1}y(z)$.

A unit time delay transforms into a multiplication by z^{-1} in the z-domain. Conversely, a unit time advance

$$y(n+1) = zy(z)$$

becomes a multiplication by z in the z-domain. Using the z transform on equation 3:

$$y(z) = \frac{x(z)}{2} + \frac{z^{-1}y(z)}{2}$$

When rearranged and expressed as the ratio of $y(z)/x(z)$ the expression is the transfer function. Calling the transfer function H(z), we write

$$H(z) = \frac{z}{2z-1}.$$

The zeros are the terms in the numerator that make $H(z) = 0$, and the poles are the terms in the denominator that make H(z) non-analytic, i.e. make G(z) tend to infinity, hence the name pole (imagine a vaulting pole standing on its end). Poles and zeros are critical frequencies at which something happens to the transfer function; as a result of poles and zeros the function changes as z varies. No real function can have more zeros than poles. For reason of stability the circuit designer must ensure the poles are placed within the unit circle.

These results can be plotted in the z-plane, where angular frequency is represented as a angle, a rotation of 360°C corresponding to the sampling frequency. A numerical example may help: suppose the sampling frequency is 1000Hz then the Nyquist frequency of 500Hz is located at the point p_1 on the unit circle.

To deduce the amplitude of the frequency response without recourse to Fourier transforms simply requires that we calculate $|H(j\omega)|$, or in plain English the magnitude of the zero vector divided by the magnitude of the pole vector, for values of frequency from $f = 0$ to fs_2 (half the sampling frequency). The net phase response is given by the argument of the zero vector minus the argument of the pole vector.

Using this rule we can produce a reasonable amplitude and phase response relatively painlessly by employing simple geometry, Fig. 10.

Remember that . . .

Remember that the magnitude and phase response of the filter was obtained by geometrical measurement. Greater precision could be obtained by calculation but the aim here is to keep the mathematics to a minimum.

To become proficient at designing in the z-plane try varying the position of the pole and then the zero. How does the frequency response vary?

I hope you find that moving the pole along the negative real axis modified the filter behaviour, transforming it into a higher-pass response. Cascading a low and high-pass filter would produce a band-pass characteristic, although a greater selectivity could be obtained by making the poles complex. Second-order digital filters have no place in this introductory account: if you wish to pursue this topic the article by J.T.R. Sylvester Bradley provides a particularly succinct exposition.

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5. AIM 65 Users Guide. Rockwell Internaitonal 1979.
6. Adams, J Feather, G.M. Microcomputer interfacing techniques (parts 3 and 4). *Everyday Electronics* September, October 1983.

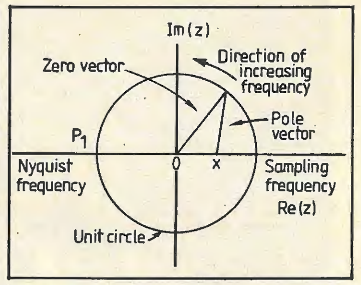

Fig. 9. z-plane diagram of the digital equivalent of a low-pass filter.

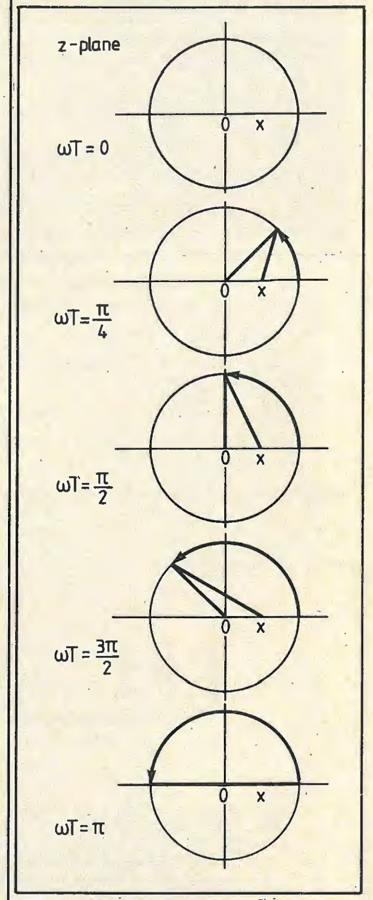

Fig. 10. As the pole and zero vectors rotate about the unit circle, so the magnitude and phase of the frequency response may be calculated for values of $\omega T = 0, \pi/4, \pi/2$ etc.

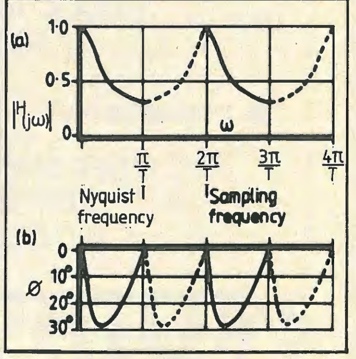

Fig. 11. Spectrum of digital filter is a repeated version of the low-pass response from $\omega = 0$ to $2\pi/T$.

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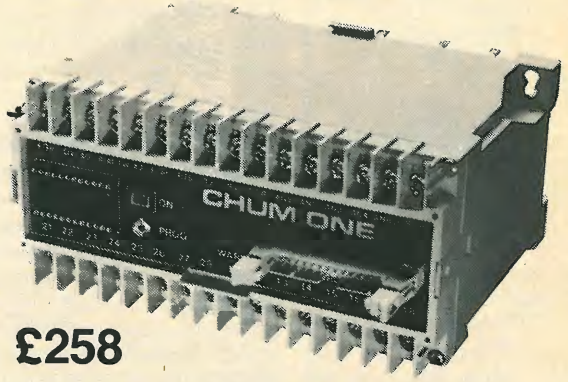

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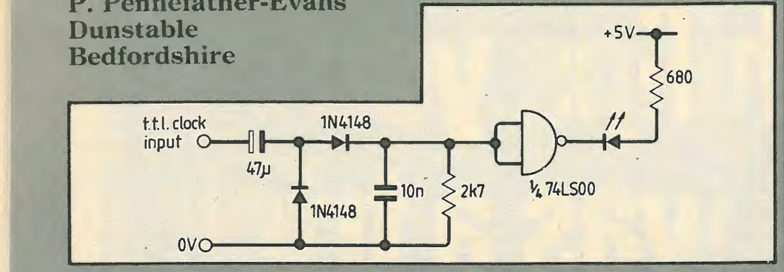


Motion detector

Motion is usually detected by taking Doppler shift measurements and require two transducers, one for transmitting and one for receiving. This circuit only needs one transducer.

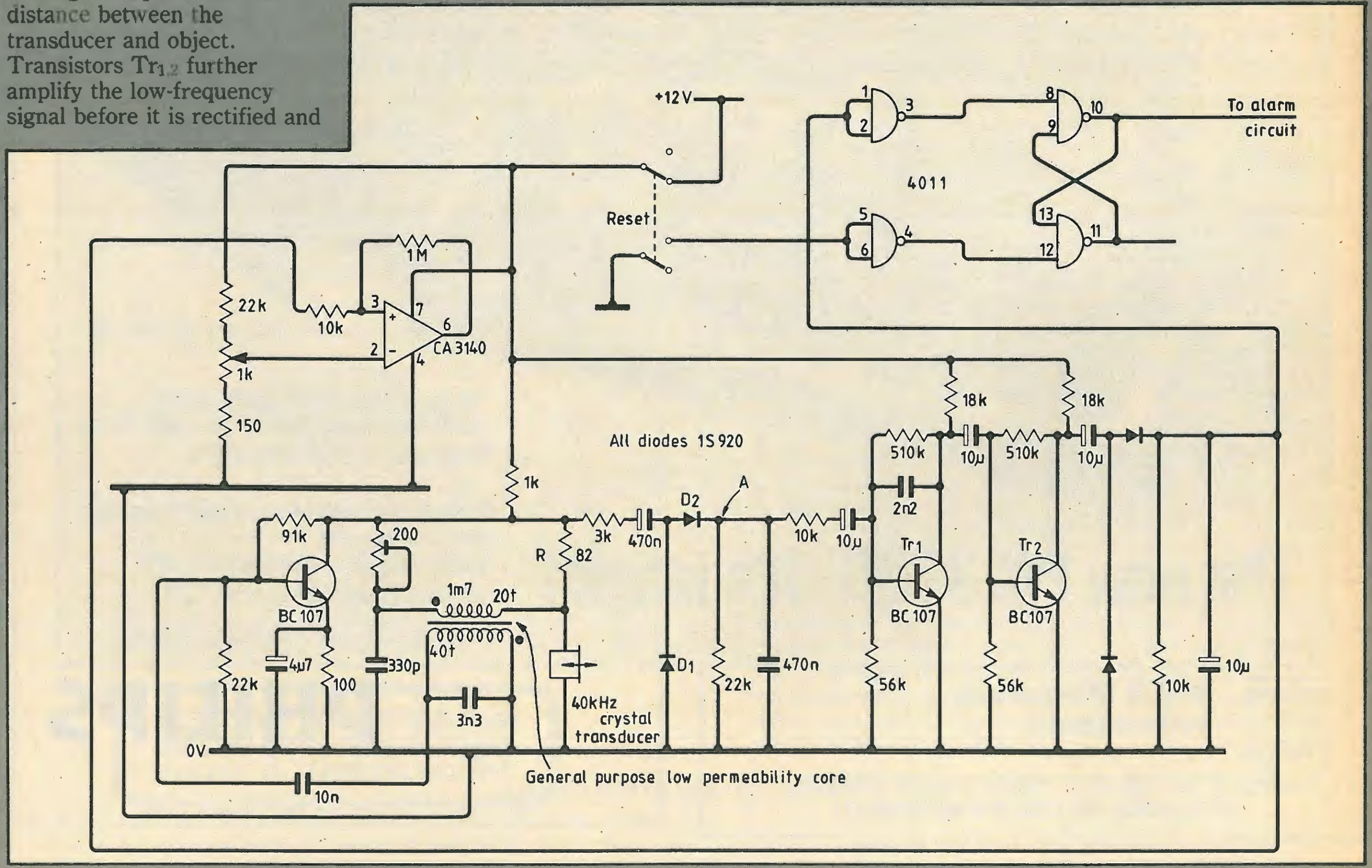
The transducer, forming part of an oscillator, determines oscillating frequency. It also forms part of a bridge circuit. Oscillator feedback voltage is determined by the voltage ratio of R to impedance of the transducer at series resonance. As shown, oscillator frequency is between 38 and 42kHz.

Output from the oscillator is rectified by $D_{1,2}$ to give a low-frequency signal. Amplitude of this signal depends on the distance between the transducer and object. Transistors $Tr_{1,2}$ further amplify the low-frequency signal before it is rectified and filtered to give a direct voltage.

Reference voltage feeding an op-amp comparator is set to cause switching when the object is at a given distance from the transducer. With the prototype, it is possible to detect a person crossing the detector path at 3m.

Alignment is easy; using a digital voltmeter, set point A to about 1V with the bridge potentiometer. Ask someone to move around at the required detection distance and adjust the comparator-reference potentiometer accordingly. The set/reset bistable circuit latches output.

R. Punter
Cleethorpes
Lincolnshire



Engine speed indication

Many medium and high capacity motorcycles now have electrical systems fed by a permanent-magnet type alternator which produces a.c. If the alternator is driven directly by the crank shaft, frequency of the alternating signal relates directly to engine speed.

Using alternator output can be the simplest way of obtaining pulses to drive an engine speed indicator. A number of modern motorcycles are fitted with integral electronic ignition systems which prohibits use of the points as a signal source and tapping a signal from the h.t. leads is also problematic.

Alternator construction varies between manufacturers but the basic design remains the same. Six coils wired in series and wound alternately in different directions form the stator. The rotor is a star-shaped magnet with alternate north-south lobes.

There are often two sets of coils on the stator, the second set being wound only on two opposing limbs and over the existing set. Battery charging is carried out continuously by the two smaller coils while the lights are powered by the main coil set under manual control.

Rectification is most often by means of a silicon or selenium-diode bridge circuit. After rectification, regulation may be performed by a large zener diode (Triumph/Lucas) instead of a switched coil; sometimes a small zener and large thyristor (Stanley) are found. Larger cycles with three-phase systems may use a thyristor bridge regulator but here, the large generator is often away from the crankshaft, driven by gears or a chain.

I carried out tests on a number of vehicles with help from my local dealer. Frequency of the a.c. output was found to be the number of crank-shaft revolutions per second multiplied by the number of alternator pole pairs, or 50Hz for 1000rev/min with a six-pole rotor. After full-wave rectification, the frequency doubles.

Using this frequency to drive a counter directly would be unacceptable due to the long delay produced by gating so I used a phase-locked loop circuit to multiply the input frequency. Having worked out how to process and display the pulses, all that remained was to find a way of sampling them that did not involve extensive modifications to the vehicle.

I tried two methods of extracting alternator pulses; both are shown. The first method involves placing a large diode in series with output from the existing bridge rectifier. This method was not so suitable due to the counter being affected by pulses from the light switch. The second method is far more effective, making use of the full set of coils, and requires only small diodes.

Rectified alternator supply is smoothed by the battery, so the signal for the pulse counter must be taken before these rectifiers, as shown. The same principle applies to star-configuration alternators using six diodes.

The potentiometer on the circuit, which should be a ten-turn type, is used to calibrate the counter. If the cycle produces 50Hz for 1000rev/min, calibration is simple using mains-derived pulses. If not, a pulse generator and frequency counter may be necessary. Accuracy to within 10rev/min was easy to obtain with the prototype. Supply-rail stabilization is needed.

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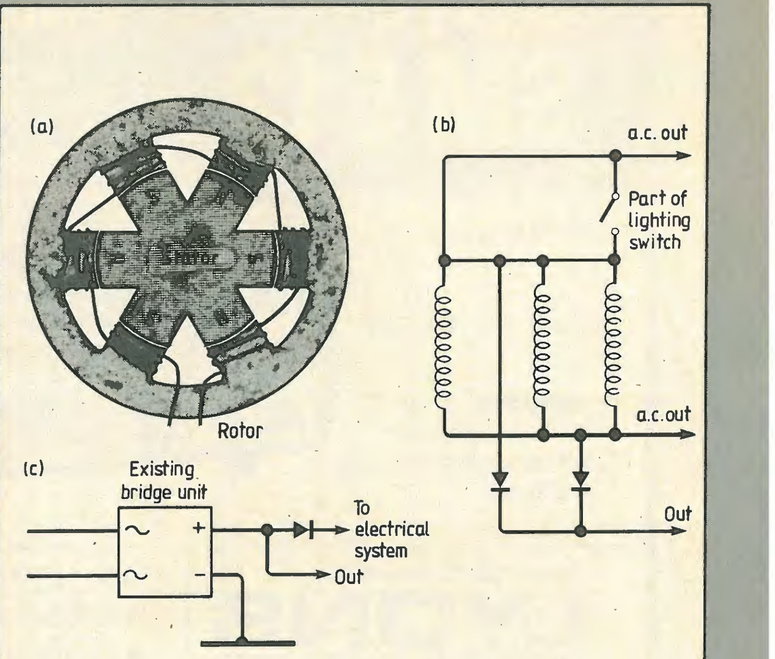

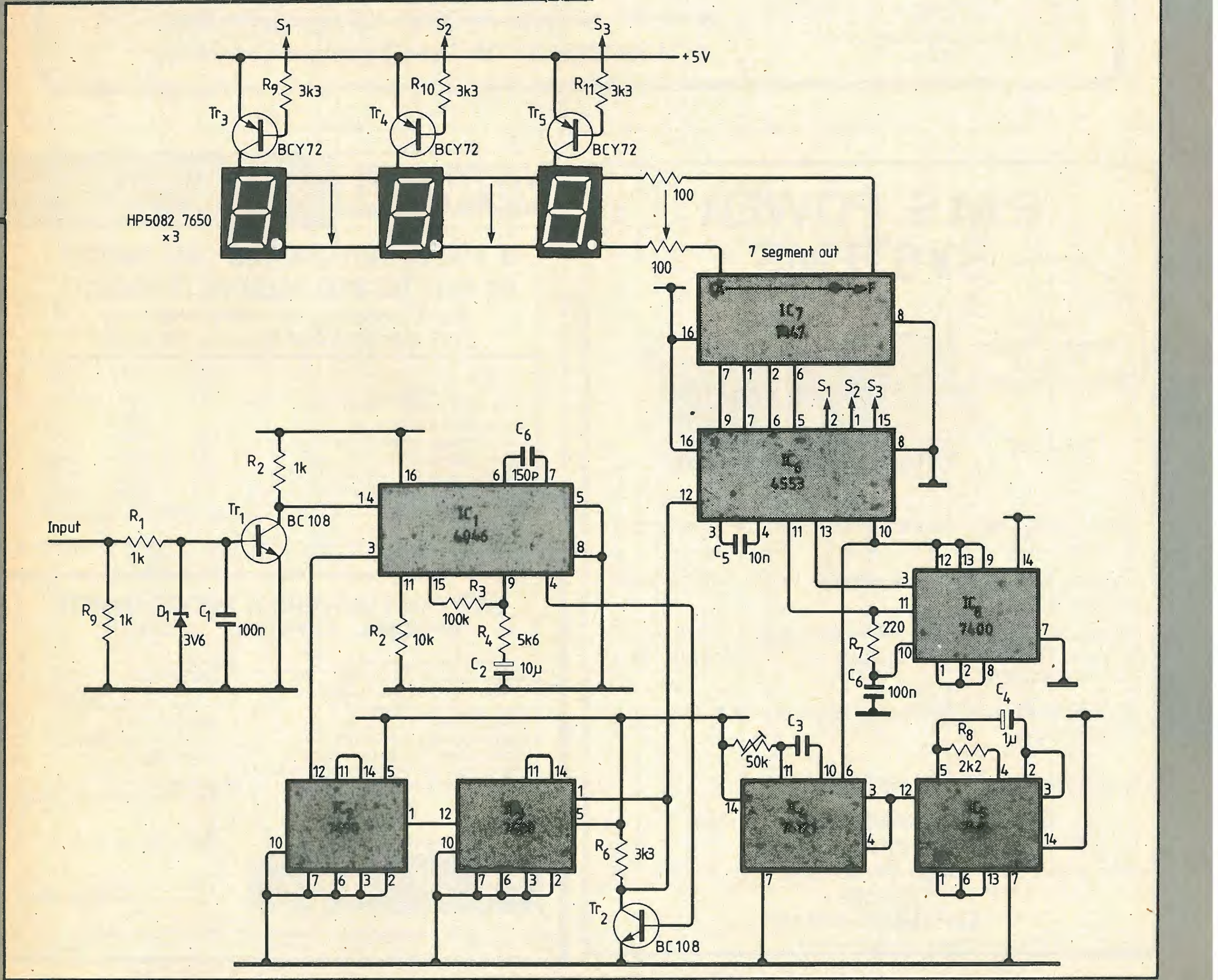

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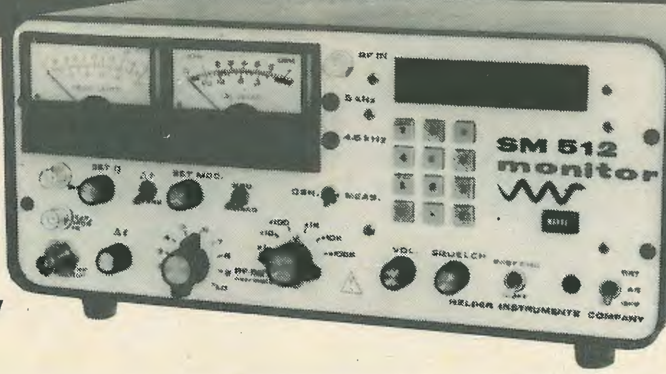

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ASY27	1.00
ASZ15	2.20
ASZ16	2.00
ASZ17	1.60
ASZ20	4.50
ASZ21	4.75
AUY10	3.50
BA145	0.13
BA148	0.15
BA154	0.06
BA155	0.11
BA156	0.06
BAW62	0.05
BAX13	0.05
BAX16	0.06
BC107	0.12
BC108	0.13
BC109	0.14
BC113	0.12
BC114	0.12
BC115	0.12
BC116	0.19
BC117	0.24
BC118	0.30
BC125	0.25
BC126	0.25
BC135	0.18
BC136	0.18
BC137	0.22
BC147	0.12
BC148	0.12
BC149	0.12
BC157	0.12
BC158	0.13
BC159	0.12
BC167	0.10
BC170	0.09
BC171	0.11
BC172	0.09
BC173	0.09
BC177	0.15
BC178	0.28
BC179	0.15
BC182	0.11
BC183	0.09
BC184	0.11
BC212	0.11
BC213	0.11
BC214	0.11
BC237	0.09
BC238	0.09
BC301	0.36
BC303	0.36
BC307	0.09
BC308	0.09
BC327	0.09
BC328	0.09
BC337	0.09
BC338	0.09
BCY30	3.75
BCY31	3.75
BCY32	3.75
BCY33	2.50
BCY34	2.50
BCY39	3.60
BCY40	3.00
BCY42	0.32
BCY43	0.45
BCY58	0.25
BCY70	0.21
BCY71	0.21
BCY72	0.21
BCZ1	3.50
BD115	0.35
BD123	2.30
BD124	2.50
BD131	0.42
BD132	0.42
BD135	0.27
BD136	0.27
BD137	0.30
BD138	0.30
BD139	0.30
BD140	0.30
BD144	2.00
BD181	0.75
BD183	0.75
BD237	0.35
BD238	0.35
BDX10	0.91
BDX32	2.00
BDY10	2.40
BDY20	1.50
BDY60	1.50
BF115	0.30
BF152	0.16
BF153	0.19
BF154	0.17
BF159	0.20
BF160	0.20
BF166	0.35
BF167	0.30
BF173	0.45
BF177	0.30
BF178	0.30
BF179	0.30
BF180	0.30
BF181	0.25
BF182	0.30
BF183	0.30
BF184	0.30
BF185	0.30
BF194	0.15
BF195	0.15
BF196	0.15
BF197	0.15
BF200	0.33
BF224	0.12
BF241	0.12
BF244	0.35
BF257	0.30
BF258	0.30
BF259	0.30
BF336	0.30
BF337	0.30
BF338	0.30
BFS21	4.00
BFS28	2.50
BFS61	0.30
BFS98	0.30
BFW10	1.04
BFW11	1.01
BFX84	0.28
BFX85	0.28
BFX87	0.28
BFX88	0.28
BFY50	0.28
BFY51	0.28
BFY52	0.28
BFY64	0.36
BFY90	0.65
BSX19	0.27
BSX20	0.27
BSX21	0.27
BT106	1.65
BTY79 400K	3.00
BU205	1.20
BU206	1.20
BU208	2.00
BY100	0.42
BY126	0.15
BY127	0.15
BZX61	0.17
Series	
BZY88	0.10
Series	
BZY91	8.00
Series	
BZY93	0.12
Series	
BZY95	1.64
Series	
BZY96	2.00
Series	
CRS1 40	0.60
CRS3 40	0.75
CRS3 60	0.90
GEX66	3.00
GEX541	6.50
GJ3M	3.00
GM0378A	1.75
KS100A	0.45
MJE340	0.79
MJE370	0.73
MJE371	1.05
MJE520	0.75
MJE521	0.73
MJE2955	2.25
MJE3055	2.00
MPF102	0.55
MPF103	0.55
MPF104	0.55
MPF105	0.55
MPSA06	0.17
MPSA56	0.17
MPSU01	1.11
MPSU06	1.33
MPSU56	1.71
NE555	0.45
NKT401	4.00
NKT403	3.50
NKT404	4.00
OA5	1.75
OA7	0.75
OA10	0.55
OA47	0.15
OA70	0.22
OA79	0.21
OA81	0.21
OA85	0.21
OA90	0.08
OA91	0.08
OA95	0.08
OA200	0.15
OA202	0.15
OA211	1.00
OAZ200	1.50
OAZ201	1.50
OAZ206	1.50
OAZ207	1.50
OC16	5.00
OC20	6.00
OC22	4.50
OC23	10.00
OC24	3.00
OC25	1.75
OC26	1.50
OC28	5.50
OC29	4.40
OC35	4.00
OC36	4.00
OC41	1.20
OC42	1.50
OC43	1.50
OC44	1.25
OC45	0.85
OC71	0.65
OC72	2.20
OC73	1.45
OC74	1.40
OC75	1.40
OC76	1.60
OC77	2.75
OC81	0.90
OC81Z	1.20
OC82	0.95
OC83	1.40
OC84	1.40
OC122	6.50
OC123	6.50
OC139	12.00
OC40	18.00
1C141	18.00
OC170	4.40
OC171	4.40
OC200	4.00
OC201	5.50
OC202	5.50
OC203	5.50
OC204	7.00
OC205	10.00
OC206	8.50
OC207	18.00
OCP71	2.50
ORP12	2.40
R2008B	1.95
R2009	2.25
R2010B	2.00
TIC44	0.48
TIC226D	1.20
TIL209	0.29
TIP29A	0.35
TIP30A	0.36
TIP31A	0.25
TIP32A	0.25
TIP33A	0.53
TIP34A	0.60
TIP41A	0.38
TIP42A	0.42
TIP110	0.40
TIP117	0.45
TIP125	0.35
TIP130	0.45
TIP131	0.45
TIP132	0.48
TIP135	0.45
TIP137	0.48
TIP140	0.85
TIP141	0.85
TIP142	0.85
TIP2955	0.60
TIP2955T	0.45
TIP3055	0.60
TIP3055T	0.45
ZS140	0.25
ZS170	0.21
ZS178	0.54
ZS272	0.23
ZS278	0.57
ZTX107	0.12
ZTX108	0.12
ZTX109	0.12
ZTX300	0.13
ZTX301	0.14
ZTX302	0.14
ZTX303	0.14
ZTX304	0.14
ZTX311	0.13
ZTX314	0.25
ZTX500	0.14
ZTX501	0.14
ZTX502	0.14
ZTX503	0.14
ZTX504	0.20
ZTX531	0.20
ZTX550	0.25
1N914	0.03
iN916	0.03
1N4001	0.04
1N4002	0.04
1N4003	0.04
1N4004	0.04
1N4005	0.04
1N4006	0.04
1N4007	0.05
1N4009	0.06
1N4148	0.03
1N5400	0.10
1N5401	0.11
1S44	0.04
1S920	0.10
1S921	0.12
2G301	1.00
2G302	1.20
2G306	1.50
2N404	1.50
2N696	0.30
2N697	0.36
2N698	0.38
2N705	2.50
2N706	0.20
2N708	0.22
2N930	0.25
2N1131	0.35
2N1132	0.35
2N1302	1.80
2N1303	0.90
2N1304	3.00
2N1305	1.00
2N1306	3.00
2N1307	1.20
2N1308	4.00
2N1309	1.50
2N1613	0.30
2N1671	5.00
2N1893	0.30
2N2147	8.00
2N2148	2.75
2N2218	0.32
2N2219	0.32
2N2220	0.22
2N2221	0.22
2N2222	0.20
2N2223	7.50
2N2368	0.23
2N2369A	0.23
2N2484	0.24
2N2646	0.75
2N2904	0.30
2N2904A	0.30
2N2905	0.30
2N2906	0.22
2N2907	0.22
2N2924	0.12
2N2925	0.22
2N2926	0.12
2N3053	0.30
2N3054	0.55
2N3055	0.70
2N3440	0.60
2N3441	0.75
2N3442	1.00
2N3614	5.00
2N3702	0.11
2N3703	0.11
2N3704	0.11
2N3705	0.11
2N3706	0.11
2N3707	0.11
2N3708	0.11
2N3709	0.11
2N3710	0.11
2N3711	0.10
2N3771	1.20
2N3772	1.20
2N3773	1.60
2N3819	0.50
2N3820	0.60
2N3823	0.80
2N3866	1.00
2N3904	0.10
2N3905	0.10
2N3906	0.10
2N4058	0.12
2N4059	0.20
2N4060	0.12
2N4061	0.12
2N4062	0.15
2N4124	0.13
2N4126	0.13
2N4248	0.25
2N4288	0.15
2N4289	0.12
2N4400	0.12
2N4401	0.12
2N4402	0.12
2N5457	0.45
2N5458	0.40
2N5459	0.40
2S017	16.00
2S019	25.00
2S024	35.00
2S025	35.00
2S026	40.00
2S103	2.50
2S302	5.50
2S303	5.50
2S322	5.00
2S324	4.00
2S701	12.50
2S745A	1.75
2S746A	1.75

VALVES

A1834	9.00
A2087	13.50
A2134	17.50
A2293	16.00
A2426	27.50
A2521	25.00
A2900	15.00
A3343	45.00
AZ31	2.75
AZ41	2.60
BK448	114.90
BK484	155.35
BS90	58.00
BS810	60.00
BT5	58.95
BT17	185.00
BT19	44.05
BT29	349.15
BT69	354.80
BT95	129.90
CBL31	4.00
CL33	4.00
CY31	3.00
C1K	20.00
C3A	22.00
C3JA	22.00
DA41	25.00
DA42	18.70
DAF91	1.75
DAF96	1.75
DET22	35.00
DET	49.00
DF91	1.75
DF96	1.75
DK91	1.75
DK92	2.00
DK96	1.75
DL92	2.00
DL94	1.75
DL96	1.75
DLS10	14.00
DLS15	12.50
DLS16	12.50
DLS19	12.50
DM70	2.00
DM71	2.00
DM160	4.75
DY87	1.50
DY802	1.50
E55L	50.00
E80CC	15.00
E80CF	11.27
E80F	14.19
E80L	13.73
E81CC	8.00
E81L	13.27
E82CC	8.10
E83CC	8.40
E86C	8.25
E88C	8.25
E88CC	10.33
E90CC	9.47
E90F	9.90
E91H	6.25
E92CC	8.75
E99F	9.10
E130L	18.50
E180CC	10.50
E180F	12.05
E182CC	13.25
E186F	11.50
E188CC	8.91
E280F	22.51
E283CC	12.00
E288CC	17.50
E810F	35.48
EA52	125.00
EA76	2.50
EA8C80	1.25
EAC91	3.50
EAF42	2.50
EAF801	2.00
EB41	4.00
EB91	1.50
EBC33	2.50
EBC41	2.50
EBC81	1.50
EBC90	1.25
EBF	1.50
EBF83	1.75
EBF89	1.50
EBL31	10.00
EC90	1.25
EC91	8.00
EC92	1.75
EC157	440.00
ECC33	4.50
ECC35	4.50
ECC40	5.50
ECC81	1.75
ECC82	1.75
ECC83	1.75
ECC84	1.75
ECC85	1.75
ECC86	2.50
ECC88	3.50
ECC89	2.00
ECC91	8.93
ECC189	2.10
ECC807	1.75
ECC808	3.00
ECF80	1.50
ECF82	1.50
ECF86	2.50
ECH35	3.00
ECH42	3.50
ECH81	3.00
ECH83	2.50
ECH84	2.50
ECL80	1.50
ECL81	1.75
ECL82	1.50
ECL183	3.00
ECL84	1.50
ECL85	1.50
ECL86	1.75
EF37	5.00
EF39	2.75
EF40	5.00
EF41	3.50
EF42	4.50
EF50	2.50
EF54	5.00
EF55	3.50
EF80	1.75
EF83	4.00
EF85	1.70
EF86	3.50
EF89	2.50
EF91	2.95
EF92	6.37
EF93	1.50
EF94	2.50
EF95	5.99
EF98	2.00
EF183	2.00
EF184	2.00
EF804S	12.00
EF805S	15.00
EH90	1.75
EK90	1.50
EL32	2.50
El33	4.00
EL34MU1	4.00
EL36	2.50
EL41	2.80
EL42	2.50
EL81	5.25
EL83	6.00
EL84	2.25
EL86	2.75
EL90	3.25
EL91	7.39
EL95	2.00
EL156	30.00
EL360	8.50
EL500	3.00
EL509	10.00
EL821	13.00
EL822	13.97
ELL80	19.00
EM34	8.00
EM80	2,50
EM81	2.50
EM84	2.00
EM85	2.75
EM87	2.50
EN32	25.00
EN91	6.50
EN92	6.96
EY51	2.75
EY81	2.50
EY83	2.50
EY84	9.24
EY86	1.75
EY88	1.75
EY500A	3.00
EY802	1.75
EZ35	1.75
EZ40	2.50
EZ41	2.50
EZ80	1.50
EZ81	1.50
EZ90	3.00
FW4-500	3.50
FW4-800	3.50
G1.371K	35.00
G551K	12.00
G180.2M	17.50
G240.2D	12.00
G400.1K	17.50
GN4	9.00
GN4A	9.00
GN4A	9.00
GS16	16.00
GT1C	25.00
GU50	20.00
GXU1	15.35
GXU2	3.50
GXu3	25.40
GXU4	44.50
GXU50	20.00
GY501	3.00
GZ32	4.00
GZ33	4.75
GZ34	4.00
GZ37	4.75
KT61	5.00
KT66	15.00
KT77 Gold Lion	12.00
KT88 Gold Lion	20.00
KTW61	2.50
KTW62	2.50
KTW63	2.50
M8079	12.34
M8080	8.25
M8081	9.82
M8082	9.69
M8083	10.25
M8091	10.43
M8096	6.80
M8097	8.10
M8098	8.15
M8099	8.00
M8100	10.30
M8136	11.75
M8137	12.25
M8140	6.00
M8141	6.50
M8142	8.75
M9144	7.50
M8149	6.50
M8161	9.35
M8162	11.75
M8163	8.25
M8190	5.00
M8195	10.85
M8196	7.50
M8204	7.05
M8212	11.37
M8223	6.00
M8224	6.30
M8225	4.50
M8248	14.03
MD2901	115.00
MU14	2.50
MX119	55.00
MX123	76.00
MX145	56.70
MX151	17.25
MX152	131.25
MX161	152.25
MX163	20.25
MX164	25.52
MX166	147.00
MX168	50.00
N78	15.00
OA2	3.25
OA3	2.50
OA4	6.00
OB2	4.35
OB3	2.50
OC2	4.35
OC3	2.50
OD3	2.50
OZ4	3.50
PC86	2.50
PC88	2.50
PC95	1.75
PC97	1.75
PC900	1.75
PCC84	1.50
PCC85	1.50
PCC88	2.00
PCC89	1.75
PCC189	2.50
PCC805	1.60
PCC806	1.60
PCE82	2.00
PCF80	2.00
PCF82	1.50
PCF86	2.50
PCF87	2.00
PCF200	3.25
PCF201	3.25
PCF801	2.50
PCF802	2.50
PCF805	1.70
PCF806	1.70
PCF808	1.70
PCL82	2.00
PCL83	3.00
PCL84	2.00
PCL85	2.50
PCL86	2.50
PCL805	852.50
PD500	6.00
PE06-40N	45.00
PFL200	2.50
PL36	2.50
PL81	1.75
PL81A	2.00
PL82	1.50
PL83	2.50
PL84	2.00
PL504 5	2.50
PL508	5.50
PL509	6.00
PL519	6.00
PL801	1.50
PL802	6.00
PY802	6.00
PY33	2.50
PY81	1.50
PY82	1.50
PY83	1.25
PY88	2.00
PY500A	4.00
PY800	1.50
PY801	1.50
QF451	82.50
QQV02-6	34.00
QQV03-10	25.00
QQV03-20A	48.38
QQV06-40A	46.00
QQV07-50	
69, 74 QQZ20	
6-4QA	62.20
QU37	12.50
QV03-12	6.80
QV04-7	3.50
QV08-100	188.00
QY3-65	63.24
QY3-125	72.00
QY4-250	74.00
QY4-400	80.00
QY5-500	199.00
QY5-3000A	472.00
QZ06-20	32.70
R10	6.00
R17	3.00
R18	3.00
R19	9.24
R20	2.50
RG3-250	32.68
RG3-250A	32.68
RG3-1250	59.00
RG4-1250	61.60
RG4-3000	99.45
RR3-250	40.00
RR3-1250	45.75
SHE12	65.00
S130	6.00
S130P	6.00
STV280-40	14.00
STV280-80	21.00
SU41	5.00
SU42	10.00
TD03-10	35.00
TD03-10F	35.00
T15	50.00
TT21	30.00
TT22	37.50
TT100	60.00
TY2-125	65.00
TY4-400	84.00
TY4-500	110.00
TY5-500	225.00
TY6-800	220.00
TY6-500A	515.00
TY6-5000B	395.00
TY6-5000W	446.00
TY7-6000A	552.00
TY7-6000W	552.00
TZ40	25.00
U18.20	3.50
U19	13.75
U25	2.50
U26	2.50
U37	12.00
UABC80	1.25
UAF42	2.50
UB41	3.00
UBC41	2.25
UBF89	1.50
UCC84	1.75
UCC85	1.85
UFC80	2.00
UCH42	2.50
UCH81	2.50
UCL82	1.75
UCL83	2.75
UF41	2.00
UF42	2.10
UF80	1.75
UF85	1.75
UF89	2.00
UL41	5.00
UL84	1.75
UM80	2.00
UY41	2.25
UY81	2.25
VLS631	15.00
XG1-2500	55.00
XG2-6400	141.90
XG5-500	30.00
XG2-6400	185.00
XR1-1600A	53.75
XR1-3200	110.00
XR1-3200A	
XR1-6400	150.00
YD1120	395.00
YD1240	490.00
Z803U	25.00
Z259	25.00
ZM1000	8.00
ZM1001	8.00
ZM1020	9.00
ZM1021	9.00
ZM1022	9.00
ZM1023	9.00
ZM1040	19.36
ZM1041	16.66
ZM1042	17.77
1B3GT	3.00
1B24	25.00
1B35A	48.00
iB63	64.00
1R5	1.75
1S5	1.75
1T4	1.75
2AS15	11.50
2C39A	60.00
2C43	70.00
2D21	3.25
2E26	8.25
2J42	98.00
2J55	245.00
2J70A	383.00
2J70B	336.00
2K25	125.00
3400Z	115.00
3500Z	100.00
3A5	3.00
3B24	11.00
3B28	15.35
3B29	20.05
3B240M	17.50
3B241M	17.50
3C23	25.00
3C24	24.50
3CX100A	47.00
3E29	45.00
3S4	2.00
3V4	1.75
4-65A	60.00
4-125A	60.00
4-250A	80.00
4-400A	87.00
4B32	20.00
4C35	120.00
4CX250B	58;00
4CX350A	105.00
4X150A	60.00
4X150D	56.00
5B254M	35.00
5B255M	35.00
5C22	160.00
5J180E	1650.00
5R4GY	5.50
5U4G	3.00
5U4GB	2.50
5V4G	2.50
5Y3GT	2.50
5Z3	4.00
5Z4G	2.50
5Z4GT	2.50
6-30L2	1.75
6AB4	1.75
6AB7	3.00
6AC7	3.00
6AF4A	4.25
6AG7	3.00
6AH6	5.00
6AK5	5.99
6AK6	2.50
6AL5	1.50
6AM4	4.00
6AM5	9.69
6AM6	6.02
6ANS	4.75
6AN8A	3.50
6AQ5	3.25
6AS6	8.66
6AS7G	8.75
6AT6	1.25
6AU5GT	5.00
6AU6	2.50
6AV5GA	4.50
6AV6	1.50
6AX5GT	3.00
6B7	3.25
6B8	3.25
6BA6	1.50
6BA7	5.00
6BA8A	4.00
6BC4	4.00
6BE6	1.50
6BH6	2.50
6BJ6	2.25
6BK4	4.50
6BL6	85.00
6BL7GT	4.50
6BM6	115.00
6BN6	2.00
6BQ7A	3.50
6BR7	6.00
6BR8A	3.50
6BS7	6.00
6BW6	6.00
6BW7	1.50
6BX7GT	5.00
6BZ6	2.75
6C4	1.25
6CB6A	2.54
6CD6GA	5.00
6CG7	2.50
6CH6	13.00
6CL6	3.75
6CW4	8.00
6D2	1.50
6DK6	3.00
6DQ6B	4.75
6EA8	3.00
6EB8	2.50
6EW6	2.25
6F6	3.00
6F23	1.60
6F28	1.60
6F33	33.50
6H1	14.00
6H2N	2.75
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7493	0.54
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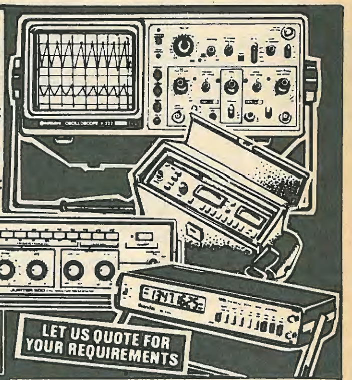

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CIRCLE 19 FOR FURTHER DETAILS.

The deeper hidden message in Maxwell's equations

by Ivor Catt

Why have Maxwell's Equations survived for so long?

In November's article[1] I investigated Maxwell's Equations, generally regarded as the greatest mathematical achievement in science.*

In the 1830s, Faraday discovered electromagnetic induction, thus closing the loop between electricity and magnetism. This discovery paved the way toward the rapid growth of electricity-based industrialization and the high technology which shapes today's world.

By making the key discoveries of their era, uneducated technicians like Michael Faraday and James Watt threatened the scholastic myth, that all progress, including scientific progress, needs must use the rigour and discipline controlled and celebrated by academics in places like Cambridge University. The ultimate in scientific rigour (*rigor mortis?*) was held to be mathematics. Biography and History of Science writings spawned in academia present the thesis that, lacking mathematics, Faraday could not and did not really effect his discovery of electromagnetic induction. Rather, he stumbled into it, but it could only be properly exploited decades later, after Professor Maxwell had placed a mathematical structure upon Faraday's fumbling, unscholarly ideas. Thus, according to the Platonic interpretation of history, Professor Maxwell, not Faraday the technician, paved the way for massive exploitation of electromagnetism in transformers, motors and generators. The deeper hidden message in Maxwell's Equations is that, do what they will, the local yokels will not replace mathematical academia as the fount of knowledge and progress.

In a previous article[1] I posed two questions:

> Do Maxwell's Equations contain any information about the nature of electromagnetism?
>
> Why do academics and practitioners generally think that Maxwell's Equations are useful?

I am sure you will have found my answers unsatisfactory. The reason is that they were based on certain assumptions, and failed to dig deeply enough into the underlying motivation, psychoses and myopia within contemporary science.

The underlying battle for the soul of science is between the practical engineer on the one hand and the Platonic pure mathematician on the other.[2] For his part, the mathematician sees this battle as more important than search after truth or technology-fuelled search after new sources of wealth. For him, the important thing is Form; the purity and beauty of his world, and his ability to control and manipulate it intellectually. (The profane aspect of this idea is the desire to impose a structure onto any 'discipline' such that it is easy to teach and, more importantly, easy to set exam questions on). One FRS told me that physical reality was composed of sine waves, and this encapsulates the mathematician's attitude to our world.

"...I was struck by the lack of any significant link between the Higher TEC syllabuses that I taught and the real subject, electronic design..."

A good example of an academic with the mathematician's attitude is Sir James Jeans. He was highly regarded in the 1930s both as a Cambridge academic and as a populist, much like Sir Fred Hoyle in the 1950s. In his book "The Mysterious Universe",[3] Jeans gives a clear view of the attitude of the Platonic mathematician discussed in the last paragraph.

> "By 'pure mathematics' is meant those departments of mathematics which are creations of pure thought, of reason operating solely within her own sphere, as contrasted with 'applied mathematics' which reasons about the external world, after first aking some supposed property of the external world as its raw material"

On the next page, Jeans goes on to write,

> "...the universe appears to have been designed by a pure mathematician."

The important thing is not to ponder over the possible contradiction between these two statements, but to grasp the mentality underlying them. This mentality, usually in a better camou..flaged and less grotesque form, is what made possible the survival of mathematical absurdities like Maxwell's Equations for such a long time.

Jeans then goes on helpfully to point out the flaw in his argument:

> "This [last] statement can hardly hope to escape challenge on the ground that we are merely moulding nature to our preconceived ideas. The musician, it will be said, may be so engrossed in music that he would contrive to interpret every piece of mechanism as a musical instrument; the habit of thinking of all intervals as musical intervals may be so ingrained in him that if he fell downstairs and bumped on stairs numbered 1, 5, 8 and 13 he would see music in his fall. In the same way, a cubist painter can see nothing but cubes in the indescribable richness of nature – and the unreality of his pictures shews how far he is from understanding nature; his cubist spectacles are mere blinkers which prevent his seeing more than a minute fraction of the great world around him. So, it may be suggested, the mathematician only sees nature through the mathematical blinkers he has fashioned for himself. We may be reminded that Kant, discussing the various modes of perception by which the human mind apprehends nature, concluded that it is specially prone to see nature through mathematical spectacles. Just as a man wearing blue spectacles would see only a blue world, so Kant thought

---

*And if mathematics is the highest flowering of science, then Maxwell's Equations become the greatest achievement in *all* science.

that, with our mental bias, we tend to see only a mathematical world. Does our argument merely exemplify this old pitfall, if such it is?

"A moment's reflection will shew that this can hardly be the whole story. The new mathematical interpretation of nature cannot all be in our spectacles – in our subjective way of regarding the external world – since *if it were we should have seen it long ago* [my italics]. The human mind was the same in quality and mode of action a century ago as now; the recent great change in scientific outlook has resulted from a vast advance in scientific knowledge and ot from any change in the human mind; we have found something new and hitherto unknown in the objective universe outside ourselves. Our remote ancestors tried to interpret nature in terms of anthropomorphic concepts of their own creation and failed. The efforts of our nearer ancestors to interpret nature on engineering lines proved equally inadequate. Nature refused to accommodate herself to either of these man-made moulds. On the other hand, our efforts to interpret nature in terms of the concepts of pure mathematics have, so far, proved brilliantly successful. It would now seem beyond dispute that in some way nature is more closely allied to the concepts of pure mathematics than to those of biology or of engineering, and even if the mathematical interpretation is only a third man-made mould, it at least fits objective nature incomparably better than the two previously tried."

Professor Einstein argued similarly in 1949[4]:

> "...the approach to a more profound knowledge of the basic principles of physics is tied up with the most intricate of mathematical methods."*

I have put the weak point in Jeans' argument above in italics. The mathematicization of science developed with a vengeance as a result of the professionalization of education. Dr Ivor Grattan-Guinness once pointed out to me that the decline, or ossification, of science into 'maturity' was a necessary result of the introduction of universal education in the mid-19th century, because it caused the growth of a powerful group with a vested interest in knowledge, the professional teachers.

Basil Bernstein[5] says that a body of knowledge is property, with its own market value and trading arrangements, to be protected by the social group which administers that body of knowledge.

If only those who lived off a body of knowledge could make that knwledge more secure, their careers and pensions would be protected. Two strategems were open to them[6,7,8]:

- to freeze the knowledge base so that it would not be a prey to the ebbs and flows of the real world, and
- to develop the thesis that any change in, or extension of, the knowledge base could only be properly effected by the professional 'knowledge magicians', 'knowledge doctors' or 'knowledge brokers', with their special, skilled, occult ways of pushing forward the boundaries of knowledge.'

"One FRS told me that physical reality was composed of sine waves, and this encapsulates the mathematician's attitude to our world."

It would of course be less effective for the professional group of knowledge brokers merely to bless or condemn influxes of new knowledge. (Admittedly they *do* do that. All my attempts to publish work on electromagnetic theory and on computer architecture (US patents 3913072 and 4333161) were blocked for more than ten years by learned journal referees, who are by definition knowledge brokers). The knowledge brokers' power would be greater if they required that new knowledge arise in their own prescribed style, preferably devised by one of their members, a knowledge professional. An early example of this in my own publications is that under threat of firing by my boss, who was also a Fellow of the IEEE, I was compelled[9] to include a ghastly, recondite, mathematical last section, written by someone else, in my 1967 IEEE paper[10].

We have reached the following point in the argument. Under cover of claiming to maintain standards of scholarship, or to maintain rigour, knowledge brokers (1) block the ingress of new knowledge, particularly revolutionary knowledge in the Kuhnian sense[11], and also (2) they make a last-ditch, bitter defence of old, discredited knowledge, like Maxwell's Equations.

> "Unfortunately, however, when the body of knowledge is bigger and the rate of inflow of new knowledge is smaller, more and more of the activity within the knowledge [base] becomes 'celebration', more and more ceremonial rather than exercise in depth. As a result, a different calibre of person is attracted to that large knowledge, lacking the ability to understand and defend a body of knowledge with many levels of meaning. They are 'maintenance men' rather than 'builders'. The central body of knowledge ossifies, becomes brittle and then disintegrates."[6]

We need to realise that the cardinals who suppressed Galileo did not need to be competent theologians or scientists; they only needed a much narrower competence, the ability to distinguish between the orthodox and the heretical, in both content and in style[12]. As to style, it is worth pointing out that possibily the ability to publish radically new, revolutionary[11] knowledge in the old accepted style would prove that after all the new knowledge was not truly revolutionary. So arguments about style, which are regularly lodged against my writing, including my last article,[1] create a beautiful Catch 22 situation where no new knowledge can be published.

In this penultimate paragraph I mention in passing The Lateral Arabesque, 'Arabesque' having the meaning ascribed to it by Dr Peter[13] rather than its dictionary meaning. In the engineering sense, the supposed situation where academia controlling a discipline – electromagnetic theory for example – maps onto the real subject, is unstable. If at any moment the professors administering a discipline happen to be weak in one branch of it, they will tend not to examine their students in it, and so will tend to select those up and coming students who have that sub-discipline as their strength. Positive feedback down the generations of students will further the retreat from that particular sub-discipline. (Sir James Jeans and Einstein could be said to be telling us very wordily that academia have selected out budding scientists who showed a grasp of the physics, rather than the maths, of their subject.) Similarly, the whole of academia will move deeper and deeper into any misconception or aberration, and there is no corrective force. In my view, 'The Lateral Arabesque' makes it possible for an academic subject's content to end up with no overlap *at all* onto the real subject from whence that branch of academia sprang. I have just completed four years as Principal Lecturer in a College of Further Education, where I was struck by the lack of any significant link between the Higher TEC syllabuses that I taught and the real subject, electronic design, in which I had been earning my living in industry for the previous 20 years. As a minor example, academia evolved the myth that dissatisfaction among logic designers with the indeterminate state of an R-S bistable if driven on both its inputs at the same time led to the development of the J-K bistable; then that the instability of the J-K led to the development of the Master-Slave J-K, regarded in academia as the Rolls-Royce of bistables. A nice idea, but with no historical foundation.

A larger example would be academia's fixation on Quine-McCluskey, something not even heard of, let alone used, by engineers in the real world of logic design. Although I was in the best position possible to introduce or alter syllabuses, being on the County Committee, during my four years as a P.L. I failed to change one word of one syllabus. I struggled very hard to do so.

To sum up. Professionalization of knowledge leads to a vested interest in knowledge,

Continued on page 75.

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*In passing, it is worth noting from page 62 of the same book, where Einstein writes: "The special theory of relativity owes its origin to Maxwell's equations of the electromagnetic field." In the literature we repeatedly come across assertions that Maxwell's Equations play a pivotal role in science.

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by R.F. Coates

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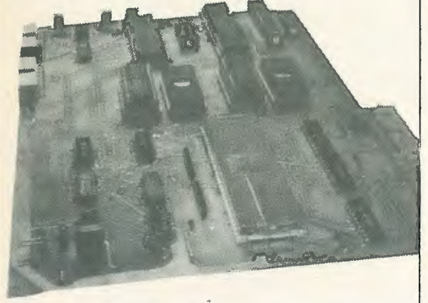

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Kaycomp accommodates two 68000 peripheral i.cs — an MC68681 dual asynchronous receiver/transmitter described last month and an optional MC68230 peripheral interface/timer. The 68230 provides digital i/o interfacing and a programmable timer, similar to the older 6821 p.i.a. or 6522 v.i.a. but much more powerful. The processor interface is similar to that of the duart, but there are no IRQ and IACK pins, and the clock for the timer is an external input which in Kaycomp is driven from the processor clock. There is also an extra register-select line RS_5 driven by address line A_5.

On the peripheral side 28 i/o pins are arranged in three ports of eight lines, PA_{0-7}, PB_{0-7}, PC_{0-7} and four handshake lines, H_{1-4}. All of these lines and the 5V supply are brought out to a 34-way connector, plug five, and are available to the user.

Some port C pins serve either as normal i/o lines or as timer/interrupt control pins, the function being selected under software control. Four of these function as the interrupt request output and acknowledge input for the timer and peripheral i/o sections of the device. Line PC_3 doubles as timer-output signal TOUT which can be used to generate an interrupt and PC_7 timer interrupt-acknowledge input TIACK. If interrupts are to be used on the i/o side, PC_5 is the peripheral interrupt request output PIRQ and PC_6 is the peripheral interrupt acknowledge signal PIACK. These four pins are not connected on the board to any interrupt pin or the IACK signal. If they are to be used, links can be made on P_6 as required.

There are certain points to be noted if using interrupts on the p.i.t. First, the IRQ outputs are not open drain but normal mos outputs and so cannot be wire-or'd with other interrupt sources, such as the duart. This means that the two p.i.t. interrupt sources TOUT and PIRQ cannot be used together on the same interrupt line. Also the p.i.t. requires that IACK only goes to the input that has caused the interrupt and not the other one, so only the one being used should be connected.

For the majority of Kaycomp applications these restrictions are not a problem It is of course possible to use one or both of interrupt lines IPL_0 and IPL_2 if they are not being used by the G64 bus. Connections between NMI/IRQ and $IPL_{2,0}$ of the processor are wire links instead of p.c.b. tracks to allow these links to be made across the board.

These restrictions on p.i.t. interrupts could not be tolerated on larger systems where it may be essential to have many devices connected to one interrupt level. This means extra arbitration logic, for instance open-collector buffers on the outputs so that they may be wire-or'd together, and gating to direct the IACK signal only to the interrupting source.

Rather than increase the complexity and cost of Kaycomp plug six, as well as being a patching area, has all relevant interrupt signals and the 5V supply brought to it. This location can be fitted with a 10-way header plug for connecting to a small separate board which implements the required arbitration logic to give full interrupt facilities. All the necessary signals are also available on plug five for convenience.

The duart IRQ output is directly connected to IPL_1 but there is a small link between two diagonally running parallel tracks just above plug five which if broken makes the duart IRQ and IPL_1 signals available separately at plug six.

Power

Requirements for the fully populated Kaycomp board are +5V at 0.7A, and positive and negative 12V rails at 30mA each. If the serial interfaces are not being used, the 12V supplies can be omitted.

Power is supplied through the G64-bus connector from the bus backplane. If the external bus is not being used then the connector could be omitted and supplies from an external power source wired directly to the board.

Circuit and component options

In its basic form, Kaycomp can be used with just the processor, ram, eprom and the serial ports, the processor clock being derived from the duart clock. A wire link is fed from the pad next to pin 32 of IC_{16} to pin 10 of IC_{14} for the clock signal. Components R_2, C_9, C_{10} and XL_2 are not fitted.

Having a processor clock of about 3.6MHz means that the slowest 68000 processor and 450ns-access or faster memories may be used. Gate IC_{14} may be either an l.s.t.t.l. type or a t.t.l- compatible high-speed c-mos device such as the 74HCT00. If a separate processor crystal is used or anticipated, IC_{14} must be a high-speed c-mos type.

I recommend that you use sockets for the larger i.cs like the processor, peripheral i.cs and memories. Remaining i.cs may be soldered in or socketed.

If your p.c.b. has plated-through holes then any type of good-quality socket may be used. If not there are a number of turned-pin socket types available that allow soldering on both sides of the board using a fine soldering iron tip. The easiest types to use are socket terminal-carriers which consist of individual sockets with no insulator mounted on an aluminium 'dummy' i.c. After soldering, the dummy i.c. is removed, leaving the individual pins in place to form an i.c. socket.

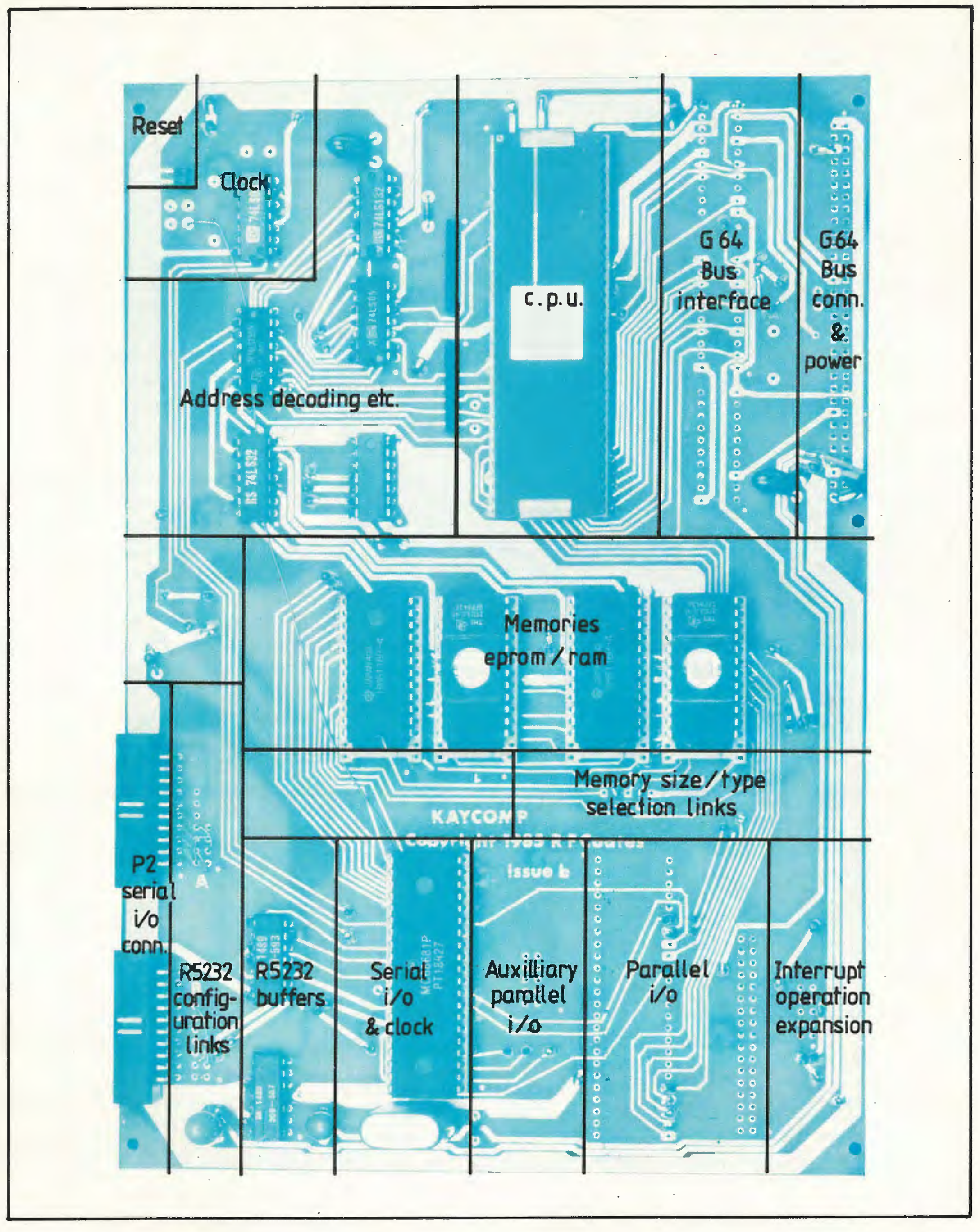
If crystal XL_2 is to be used to take full advantage of the speed of the board then IC_{14} must be a 74HCT00 and C_9, C_{10} and R_2 must be fitted. Crystal frequency is chosen to suit your needs and the speed selection of the processor and memories used. At present 68000 microprocessors are available with 4, 8, 10, 12.5 and 16MHz maximum clock rates. The board was designed to be used with an 8MHz crystal, but the clock oscillator will work down to 2MHz. In practice the boards have been found to work up to 10MHz satisfactorily.

The 68000 peripheral devices will work with any clock speed, as the asynchronous bus transfer technique means that access to these chips will be slowed down to suit them, but the memories must be capable of operating at the appropriate speed. Maximum access times of devices that may be used at various crystal frequencies in nanoseconds are 660 for 4MHz, 290 for 8MHz and 230 for 10MHz.

The 'Kaybug' monitor fits into two 2732 eproms, but these are most commonly available with 450ns access times. This though is the worst case and in practice, 450ns devices tried in prototype boards have always worked satisfactorily at 8MHz although this cannot be guaranteed, of course.

If peripheral i/o is required then IC_{15}, the MC68230, must be fitted. A socket should be used here, but 48-pin sockets are not very common so it may have to be built up using socket strips or by using two 24-pin sockets mounted end-to-end. A connector for the i/o lines will also be required, this being a 0.1in 34-way straight p.c. mounting plug.

Three i.cs, IC_{11-13}, resistor R_1 and the bus connector need fitting if use is to be made of the G64 bus. It is also worth noting that if the G64 bus interface is fitted it is possible to use the board without the two on-board serial ports, allowing IC_{16-18} and X_1 to be omitted. A special version of the Kaybug monitor is available on request which instead of using the on-board ports for terminal and host communication uses a G64 dual serial interface card instead, the Thomson EFS-SI01.



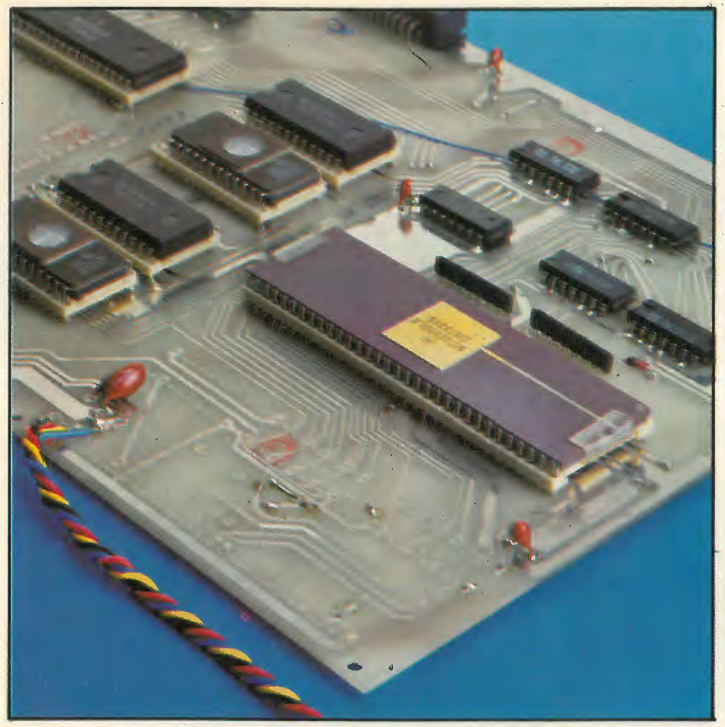
All resistor and resistor network values quoted are typical and are not critical, as are all capacitors with the exception of C_7, C_9 and C_{10}. Holes are provided at each corner for monting the board if required, or of course the board will fit a standard 6U-high Eurocard rack. In this case a Vero KM6 card front panel may be fitted using the two front mounting holes.

Construction is straightforward provided that the printed circuit board designed for the project is used. Using strip board or wire-wrap could prove a false economy and it may not be possible to achieve correct operation due to the high speeds involved on the board.

These construction details assume that you are building the fully opulated board. After inspecting the bare p.c.b., there are three insulated cross-board links which may need to be fitted. If G64 NMI and IRQ lines are to be applied to IPL_2 and IPL_0, then fit wire links A-B and C-D respectively. These letter references are on the p.c.b. component position diagram supplied with the kit. Components IC_1 and IC_{12} fit over the top of the links to hold the wire in place. If a separate processor clock crystal is not needed, a wire link should connect point E next to IC_{16} to the holes for C_{10} nearest to IC_{14}.

Next, optional connectors PL_{1-3} and the i.c. sockets are fitted. The memory sockets should be fitted in the order IC_3, IC_5, IC_2 and IC_4. Sockets for $IC_{1,16}$ and optional IC_{15} are fitted in the same manner.

Now fit connectors P_{5-7}, as required. If you do not intend to change the memory types or the serial port configuration then wire jumpers can be used on links one to three. If changes are anticipated, fit wire-wrap pins instead. Resistors,



capacitors, resistor networks, D_1, PL_4 (reset) and the optional crystals come next.

Finally, gating chips $IC_{6\text{-}10,14}$, serial interface i.cs $IC_{17,18}$ and optional bus interface devices $IC_{11\text{-}13}$ should be soldered in, completing the board.

If power is derived from the G64 backplane, PL_1 is not fitted and the power leads are connected in the holes of PL_1 as follows; 0V to 32a and 32b, +5V to 31a and 31b, +12V to 30a (nearest board edge) and –12V to 30b.

Getting started

Before inserting the expensive i.cs, power up the board to make sure that there are no power-rail short circuits. Connections must be made on links $LK_{1\text{-}3}$. The first link needs to be configured according to the memory types being used, as shown on the circuit diagram in last month's article. The second and third links may be more of a problem. You will need to take into account requirements of the terminal to be used.

The Kaybug monitor program uses transmit data and receive data lines without handshaking, RTS output being permanently asserted, but the handshaking input and output lines are available. As a minimum requirement, only pins 1a and 3a may need to be connected. If the terminal receives data on pin three and transmits on pin two, which is the most common, then make links 1a-2b and 3a-1b. If it's the other way round, make 1a-1b and 3a-2b.

Many terminals require some input on either DCD, pin eight, or CTS, pin five. A suitable signal is available at pins 2a of the second and third links. It may require some trial and error to get things right. The most common configuration is 1a-2b, 2a-4b and 3a-1b.

Components $PL_{2,3}$ are 20-way 0.1in insulation-displacement connector plugs; 25-way D-type connectors are normally used for RS232 interfaces. Pin numbers of $PL_{2,3}$ though correspond to appropriate pin numbers on a D-type connector. If a terminal lead is made up using ribbon-cable connectors with a 20-way 0.1in insulation displacement connector at one end and a 25-way D-type i.d.c. (male or female to mate with the terminal) at the other, pin one on the 20-way connector coincides with pin one on the 25-way one.

Circuits $IC_{1\text{-}5,16,17}$ can now be fitted in their sockets. Make sure the upper and lower byte eproms are in their appropriate sockets.

If a Thomson EFS-S101 card is being used for serial communication instead of the on-board duart then this too will have to be configured to suit the terminal and the data rate set as described in the manufacturer's manual. Address switches on the EFS-SI01 card J3 and J4 should be set to F and E respectively so that the board occupies addresses FFFFF1 to FFFFF7.

Port P_1 is used for the terminal and P_2 for the host system if required. With both types of serial interface characters have eight data bits, no parity bit and one stop bit, which the terminal should also be set to.

At switch on, if the EFS-SI01 card is being used you should be greeted with a sign-on message and prompt on the terminal if all is well. With the stand-alone board though nothing will happen.

Kaycomp's serial interface has no data-rate selection hardware, this function being performed in software. At power-up (or reset) before anything can be sent to the screen, the monitor software must determine the terminal data rate. This is done by the operator hitting the carriage return key repeatedly.

The monitor reads the characters in, stepping through the available rates until the carriage return code is correctly interpreted. It then holds the data rate at that value and sends the sign-on message and prompt to the terminal. Data rates available with the keybug monitor are 19200, 9600, 4800, 2400, 1200, 600, 300, 150, 110 and 75 baud.

The second serial port on Kaycomp works identically to the first and may be used for connection to a host computer. Data rate for this port is set at reset to be the same as port A but it is possible to alter this by software if required. On the external serial card, data rates are set individually by jumpers and so it is possible to set the two ports differently.

Care should be taken if the host port is at a higher rate than the terminal as the host could send a stream of data faster than it could be transferred to the terminal. Although no hardware handshaking is supported by the monitor, it supports XON/XOFF protocol to suspend output which allows slow terminals such as those with smooth scrolling to be used at high rates.

Software for the 68000-board monitor is discussed in the next article.

Events

22 November
Marconi — triumph of a non-conformist: Royal Institution lecture, Royal Institution, Albermarle Street, London W1. 21h. Tel. 01-493 6470.

25 November
Propagation above and below the waves: IEE colloquium.
Improving prediction methods for radio services in u.h.f. and v.h.f., bands: IEE lecture.

26 November
The Janet project (networking in universities and colleges) IEE colloquium, 10h.

27-28 November
Measurements for telecommunications transmission systems. IEE/IMA/IoP/IERE International conference at the IEE Savoy Place.

27-29 November
ITAME: International test and measurement exhibition Olympia 2, London. Tel. 0280 815226 or 0799 26699.

29 November
Real-time expert systems for process control: IEE colloquium, University of Salford. 1030h.
UK research into robotics and automatic manufacture: IEE/IMechE/SERC seminar at Savoy Place.

3 December
Impact of i.k.b.s. on designers: IEE/Design Council discussion meeting, 14h.

3-4 December
Satellite communications: Conference at the Tara Hotel, London. Details from Online, Tel. 01-868 4466.

4 December
Electrostatic damage in semiconductor devices. IoP/IEE one-day meeting at Imperial College, London. Tel. 01-235 6111.

4-5 December
Electric and magnetic fields in medicine and biology: International conference at Savoy Place.

5 December
Automatic test technology for electronic devices and boards. IEE colloquim, 14h.
History of sound broadcasting: IEE lecture.

6 December
Energy sources for portable telecommunication equipment: IEE colloqium.

9 December
Cross polar cancellation techniques: IEE colloquium.

10 December
EMP protection: IEE colloquium, 1030h.
What is MAP? IEE lecture.

12 December
The application of real-time Basic and Forth to control systems: IEE colloqium.

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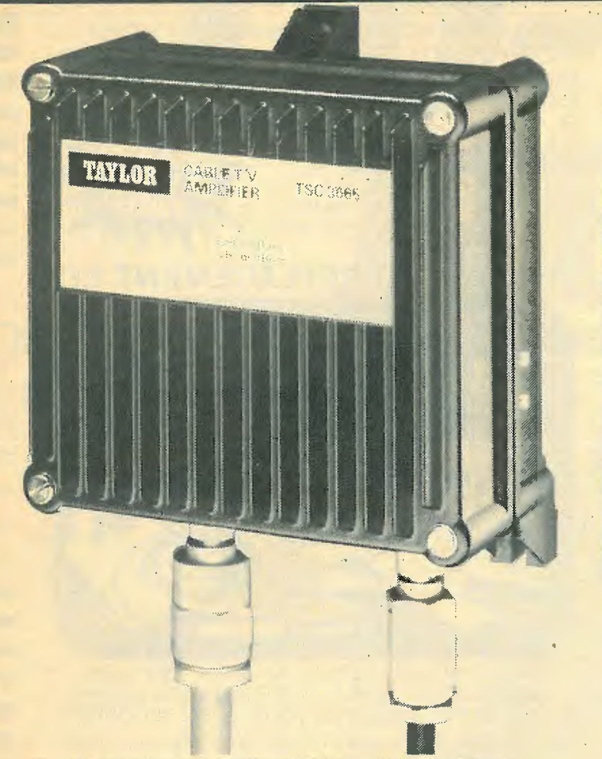

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TSC3660	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv)	+ or – .5dB	5dB VHF — UHF	27-42V 18VA~
TSC3660SM	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv)	+ or – .5dB	5dB VHF — UHF	25-45V 13VA~
TSC3665	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv) VHF 65dB (1800mv) UHF	+ or – .5dB	5dB VHF — UHF	24-42V 24VA~
TSC3665SM	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv) VHF 65dB (1800mv) UHF	+ or – .5dB	5dB VHF — UHF	25-45V 18VA~

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EZV12	40-300	12dB	1dB	EZU12	470-860	12dB	1dB

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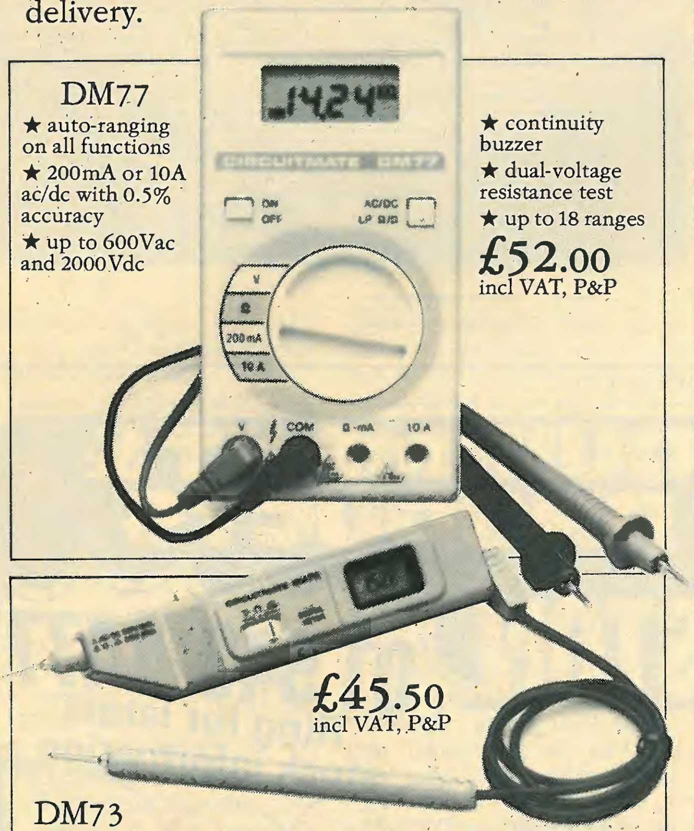

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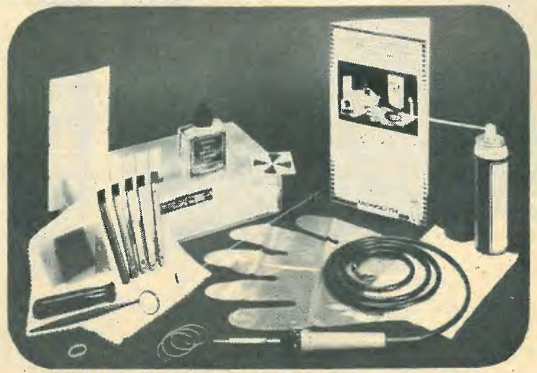

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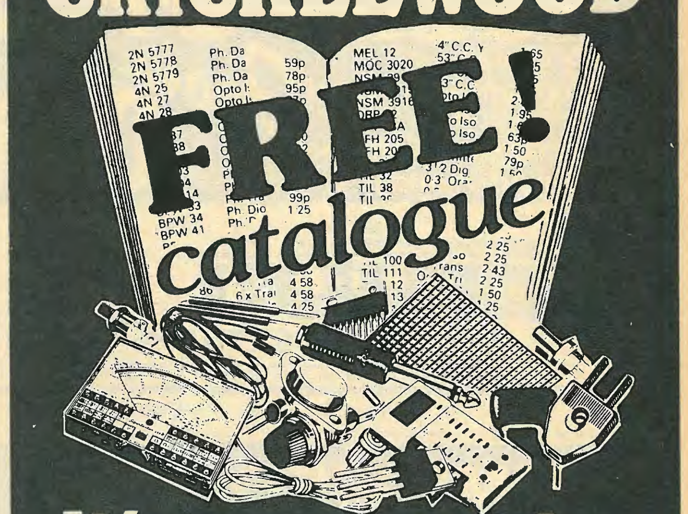

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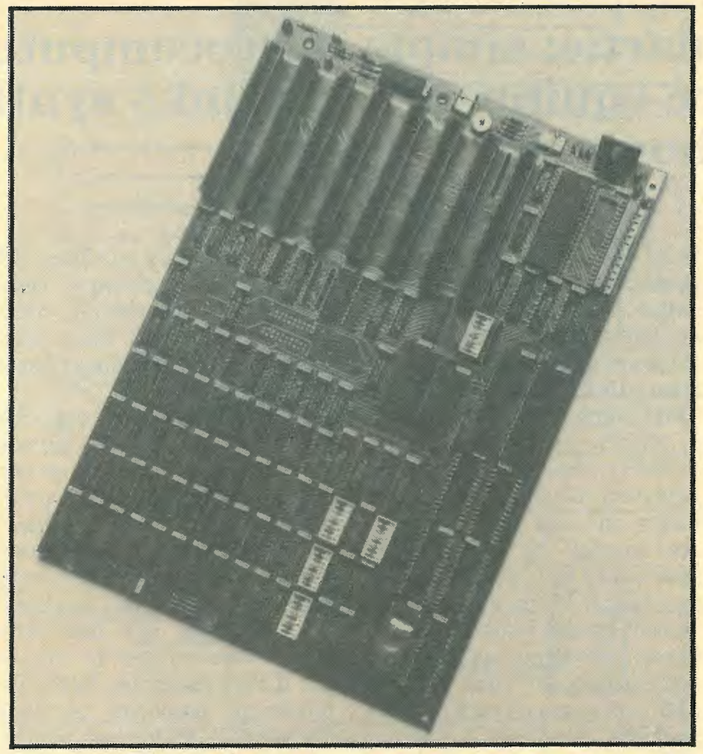

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CIRCLE 32 FOR FURTHER DETAILS.

Computer-controlled radio receiver system

Introducing Smartie: simple microcomputer and radio tuning interface equipment that links synthesized receiver with home computer.

by D.W. Harris B.Sc., F.I.E.E.

After gaining his degree in Electronics from Southampton University in 1970, Dave Harris, who is 36, worked for the BBC until he joined Radio Botswana in 1984. Appointed Chief Engineer two years later, he became Botswanna's Deputy Director of Information and Broadcasting in 1980 working on the expansion of domestic broadcasting until his return to the UK at the end of last year. He hopes it is only the current recession in the broadcasting industry that has so far prevented him from obtaining full-time employment in the UK and professes to be torn between engineering consultancy and community radio. His hobbies include musical composition, drama, playing jazz, computing and amateur radio. This article is based on a paper he wrote "somewhat tongue-in-cheek" for the 1984 conference of the Commonwealth Broadcasting Association.

Sony's ICF2001 is typical of a modern generation of domestic radio receivers designed around synthesized oscillators. It covers the m.f. and h.f. bands from 150kHz to 30MHz in 1kHz steps, as well as band II in 100kHz channels from 76 to 108MHz. Its internal tuning, keyboard handling, display circuitry and any other features are handled by a variety of specialized l.s.i. chips resulting in a design which, despite some selectivity and front-end limitations, represents an amazing achievement in such a small and relatively inexpensive package.

The Sony receiver has been reviewed on various occasions – ref. 1 reproduces the circuit diagram and so this article does not dwell on the circuitry. There are 28 keyboard buttons which allow direct entry of frequency, selection of preset channels, scanning limits, fast and slow tuning, and so on. External control of the functions of these buttons allows a multitude of applciations, enhanced by access to the receiver's a.g.c. line.

The BBC microcomputer is also well-known and has rapidly established itself as a versatile controller thanks to its excellent input-output facilities. Of particular interest to the present application are the eight-bit user port, the internal timer and the analogue-to-digital converters. Simple interfacing allows operation of the receiver under program control.

The ICF2001 keys are scanned through the conventional multiplexing arrangement found in calculators and computers. Eleven individual key lines are switched to one or other of two main bus lines, K3 and K4, Fig. 1, giving 22 combinations. The remaining functions are provided via a third bus-line, K2, or as direct hardware switches.

Analysis shows that only one of the eleven K3/K4 switches may be validly pressed at any one time; it may be necessary to simultaneously press the 'fast' or 'enter' keys for such functions as storing a frequency in memory or rapid scanning. This suggests the use of a 4-to-16 line decoder to control the K3/K4 functions. In the interests of simplicity no other decoding is performed for the remaining bits of the port.

Interface details

Complementary mos4016 quad switches simulate the operation of the press buttons. These are controlled either directly from the 6522 port in the BBC micro or via 7404 hex inverters from a 74154 4-to-16 line decoder which is itself operated from the lower four bits of the user port.

An intermediate bus-line, not directly accessible from the computer, allows either K3 or K4 to be connected to any one of the associated 11 lines. The 4016 associated with the K2 switches ('fast' and 'enter') are directly controlled by bits 6 and 7 of the v.i.a. whilst bits 4 and 5 are used for K3 and K4. See Fig. 2 for the circuit diagram.

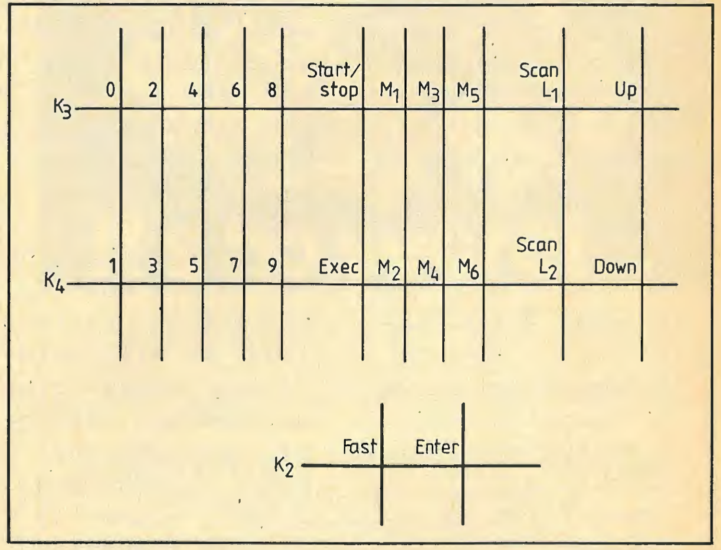


Fig. 1. The keyboard-scanning matrix for the Sony ICF2001 receiver is similar to that found on calculators and computers. Lines K2, K3 and K4 are bus lines from the receiver's microcomputer.

The receiver's a.g.c. line is brought out separately and in the prototype connected to channel 1 of the computer's analogue-in socket. Threading this line a few times through a small toroid helps reduce r.f. 'hash' picked up by the radio from the computer. Incidentally, it is practically impossible to eliminate such interference; pickup on the ribbon cable to the keyboard and directly by the aerial gives a permanent background buzz on most channels, which fortunately is easily over-ridden by any reasonable signal picked up on a short external aerial. Experimentation with earthing arrangements can significantly improve matters.

Power for the interface is derived from the computer +5V line; the Sony can be used with its own mains power supply but there is some advantage in constructing a small (600mA) regulated 5-volt supply to eliminate the effects of mains voltage changes over long periods. The prototype interface was constructed using wire-wrap techniques and housed in a suitable die-cast box.

Software

BBC Basic features named procedures and these can be used extensively to give an easily documented control program. For example simulating the pressing of key 9 requires:

```
DEF PROCkey9
?&FE62=&FF: REM all v.i.a.
  lines configured as outputs
?&FE60=&27: REM put a
  short across K4 and key 8/9
FOR delay=1 TO 100: NEXT:
  REM short delay to allow
  Sony to respond
?&FE60=&00: REM release
  the button
FOR delay=1 TO 100: NEXT:
  REM delay as above
ENDPROC
```

It is then a simple matter to make up any sequence of key presses, such as

```
  PROCKEY 7:  PROCkey 2:
  PROCkey5: PROCkey5:
  PROC-  execute:
  REM 7255kHz
```

which happens to be the frequency for Radio Botswana's 41 metre domestic short-wave transmissions!

Direct manipulation of the v.i.a. registers as above is not 'legal' across Acorn's Tube interface; if necessary the appropriate osbyte call (&97) should be used (see page 468 of ref. 2).

Having set up a frequency on the Sony, adval readings may be taken as frequently as the computer can handle the conversions – i.e. every 10 ms if necessary and if *FX16 is set appropriately – but take care to allow the a.g.c. line to settle down after a change of frequency e.g. when sequencing around the memory buttons. A settling time of about one second has been found appropriate in such cases.

Applications

Probably the easiest application is the use of the apparatus for simple chart recording of field strength, which can be performed at whatever sample interval is felt appropriate. In this case although the computer has very little work to do during the recording process, it can be used for subsequent analysis of the data. For example, raw samples could be taken several times per second to allow detailed investigation of fading, but equally useful information could be deirved from the same data by smoothing it using a running average (such as is done with the sunspot number). This would be difficult to achieve with conventional

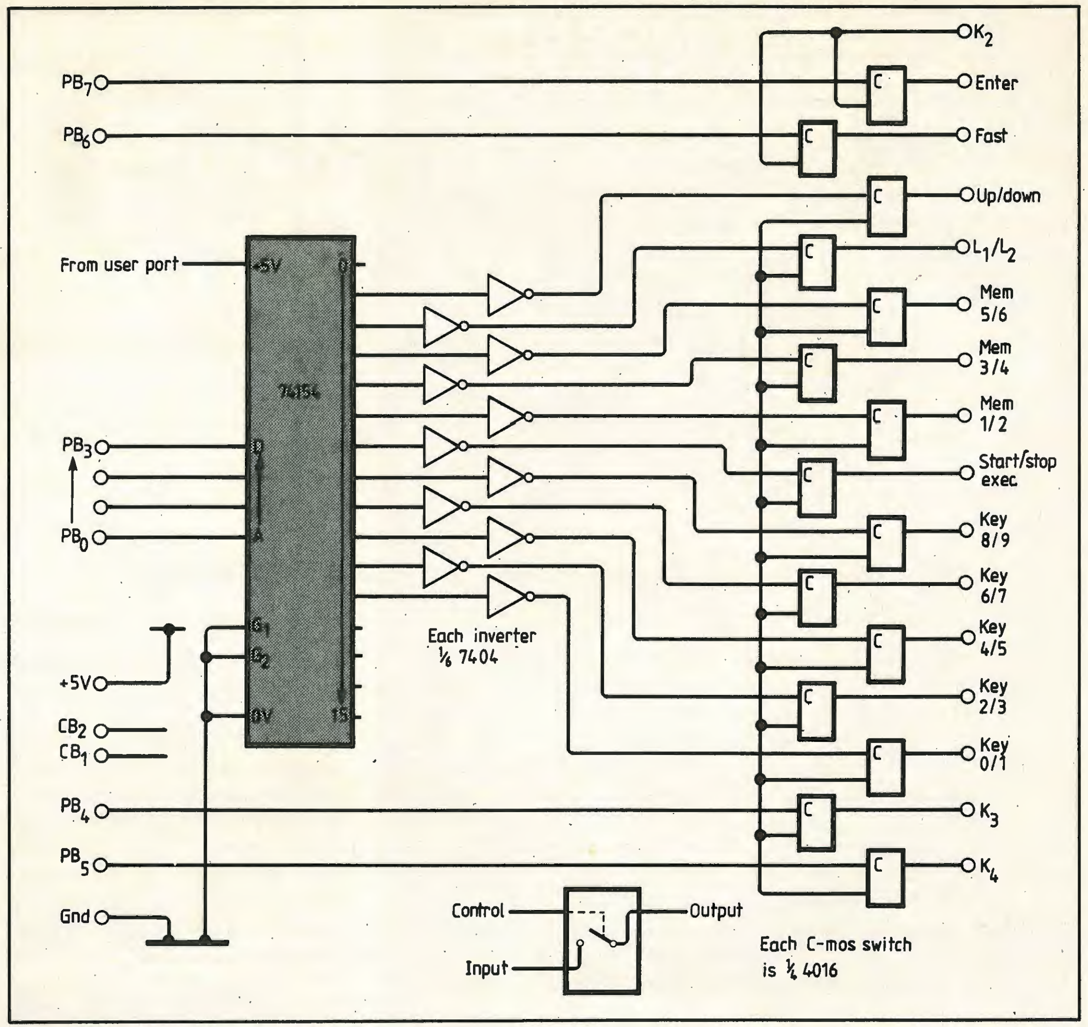
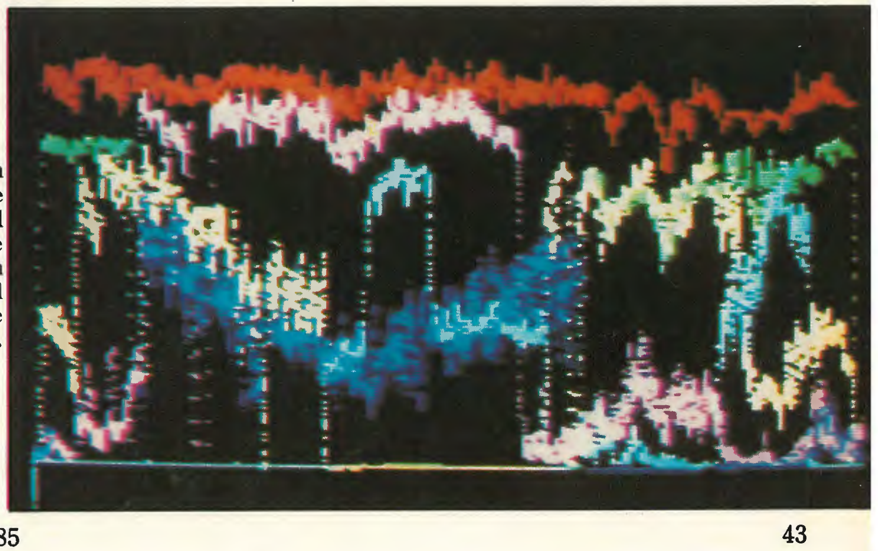


Fig. 2. Circuit diagram of the Smartie interface between the BBC micro user port and the keypad on the ICF2001. Type 4016 c-mos switches make the connections and simulate operation of the push buttons.

Typical off-screen photograph is an alternative to the screen dumps of Figs 3 & 4.



Program listings in Basic for the applications discussed are obtainable from the editorial office, in return for a stamped and addressed envelope marked 'Smartie'.

References

1. Poel, W. Sony's ICF2001. *Radio & Electronics World* Nov. 82. p. 46.
2. Coll, J. The BBC Microcomputer User Guide. BBC.
3. Ward, B. BBC Micro System User Guide. BBC.

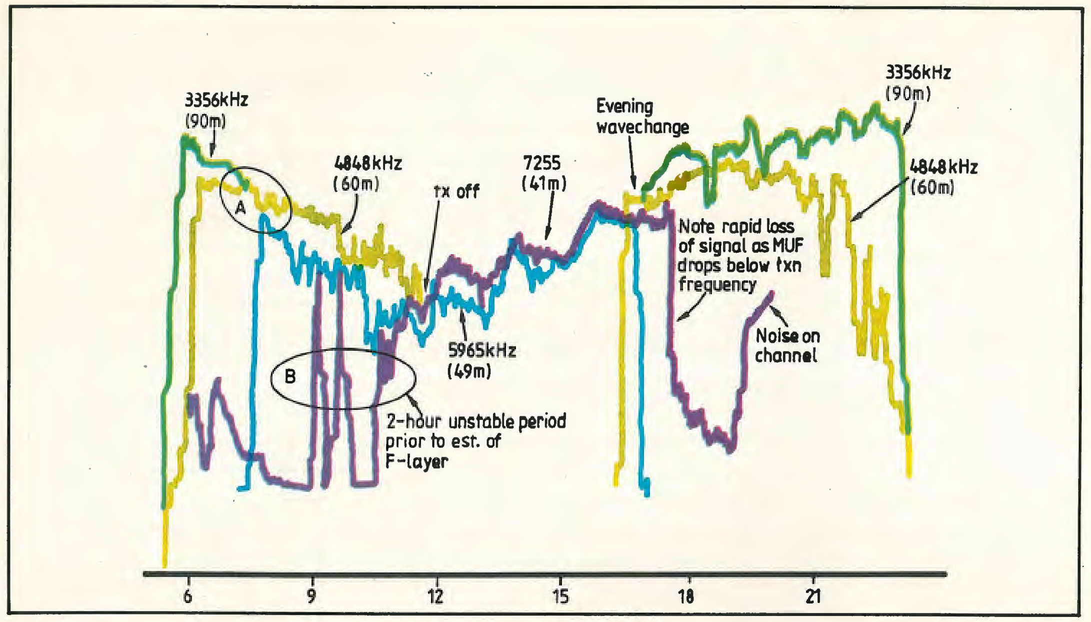


Fig. 3. Signals monitored at Serowe (250km from transmitters) on 27 October 1984 show propagation characteristics of the different frequencies, which can easily be compared with each other and the theoretical predictions. Normally such monitoring would require four separate receivers and chart recorders and superposition would be difficult.

Fig. 4. As Fig. 3, but the following day. Note the differences, notably in propagation of 7255kHz (41m).

paper chart roll and would in any case be impractical with a short sampling interval because of the length of chart likely to be generated. Calibration accuracy is of course limited by the receiver and no-one would seriously consider this as a replacement for a conventional field strength meter.

Such a task, however, hardly begins to utilise the power of the Sony/BBC micro combination. A simple spectrum analyser is achieved by pulsing the up/down buttons and keeping track of the frequency at the same time with the computer. This idea can be extended to generate the band occupancy charts beloved of h.f. monitoring stations and may of course be used to find clear frequencies for forthcoming schedules.

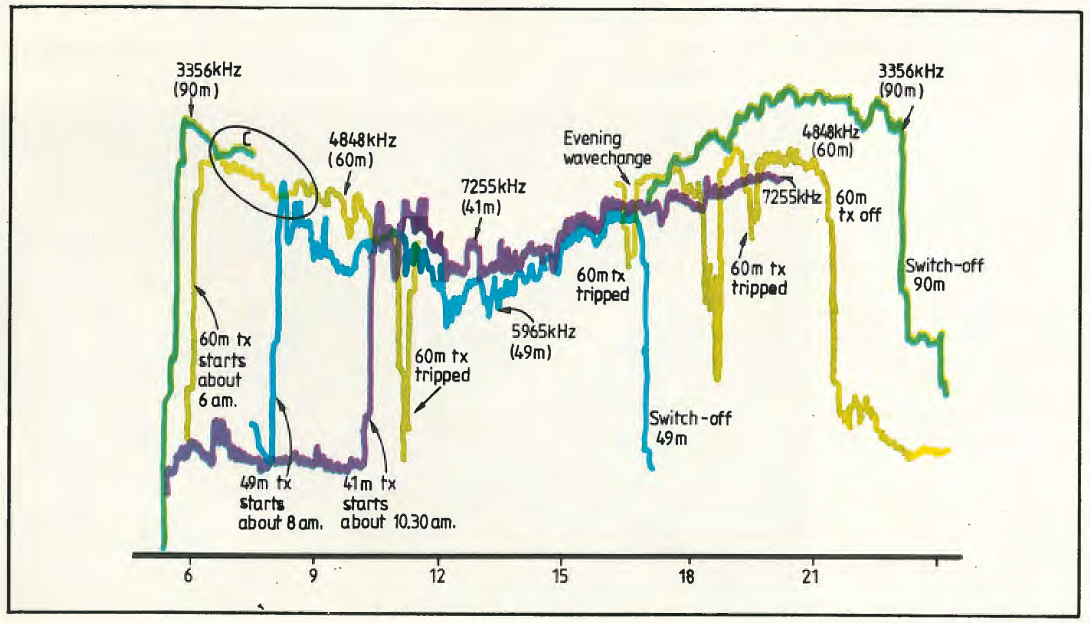
A completely different application is that of sequential monitoring. In this case the memory preset buttons are preloaded with the various frequencies in use by the station and the computer simply steps around them in an endless loop. Audio output from the Sony may be taken to a monitor loudspeaker or a data logging tape machine (a Racal Autostore is used by Radio Botswana with excellent results), or a.g.c. output used to detect carrier failure. The cost of a purpose-built sequential monitor is of the same order of magnitude as the Sony/BBC combination!

Program 1 illustrates an even more interesting use*. This is a combination of the previous two: the preset memory buttons are loaded with frequencies to be monitored and then a continuous sequential scan is made of these memorized frequencies whilst taking a.g.c. readings. The readings, with time markers inserted every minute or so, are stored sequentially (256 at a time by the BBC disc filing system) on a floppy disc. When replayed with a suitable analysis program (e.g. program 2) the various frequencies can be de-multiplexed and then separated from time markers to simulate a multichannel chart recorder.

Typical output from this program is shown in Fig. 3 and 4 in the form of screen dumps taken from a colour monitor. In the original recordings seven transmissions were monitored over two successive days; for clarity the analysis program has selected for display only the short-wave frequencies transmitted to the area at any given time. It is possible to see at a glance the propagation efficiency of all the transmissions over a complete day – four in this case but it could have been more – essential information for planning times of frequency changes and comparing actual reception with predictions. In particular the time at which propagation to a given area fails as the operating frequency drops below the m.u.f. (or to be more accurate, the h.p.f.) can be seen very clearly and this information may then be extrapolated for other distances in accordance with the well-known secant law. Such observations, if taken carefully, are a valid substitute for ionosonde data which may be otherwise unobtainable.

The vertical axis of Fig. 3 and 4 is arbitrary for three reasons. Firstly, the Sony a.g.c. voltage is dependent on incoming supply voltage. When the unregulated Sony accessory a.c. adaptor is used this can be easily seen in the correlated movement of two or three channels, particularly the lower frequency ones where computer buzz is measured in the absence of genuine transmissions. Secondly, the inherent sensitivity of the Sony varies across its extensive frequency range, and even if this were negligible, corrections would be needed for the antenna in use.

continued on page 87.



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*See note on page 43.

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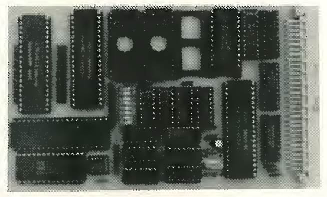

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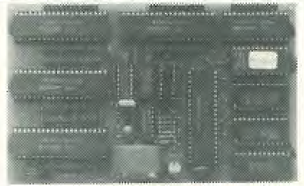

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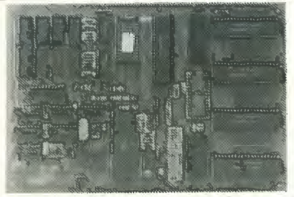

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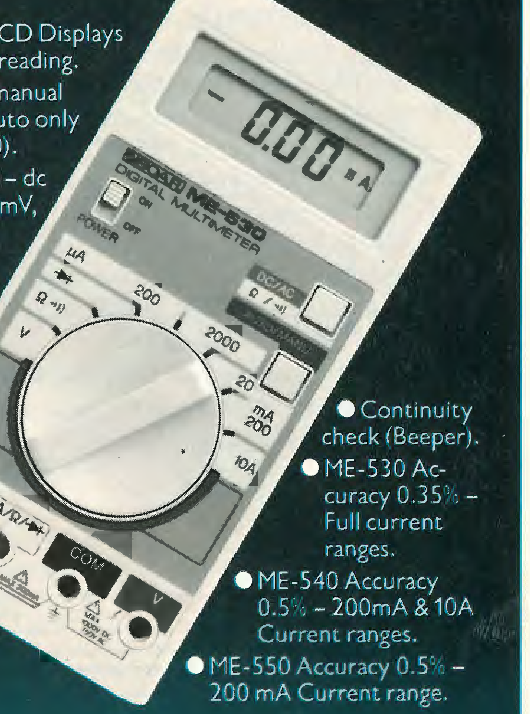

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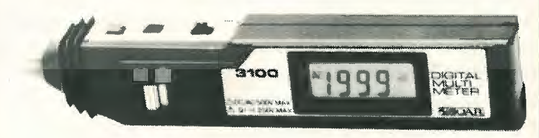

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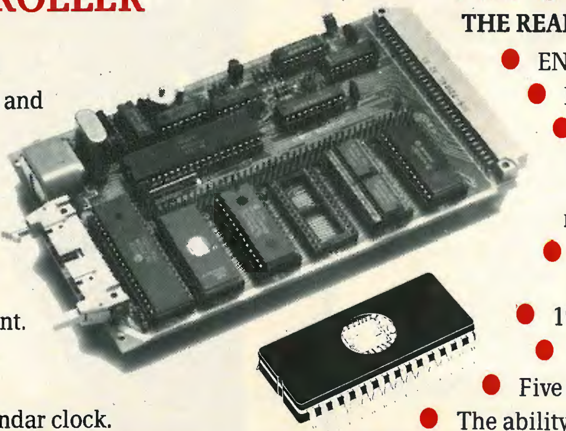

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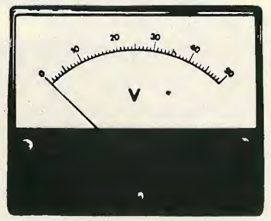

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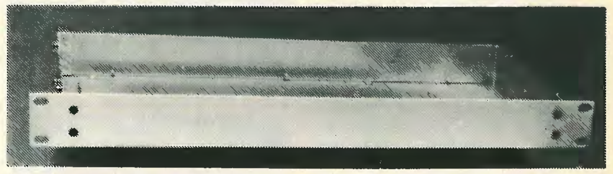

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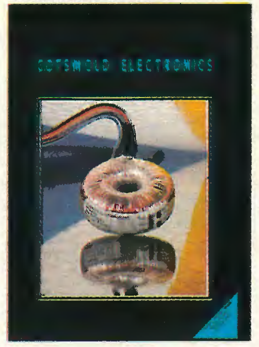

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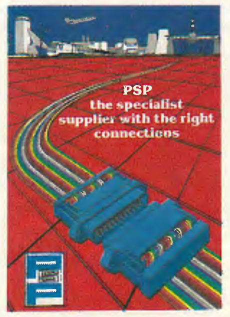

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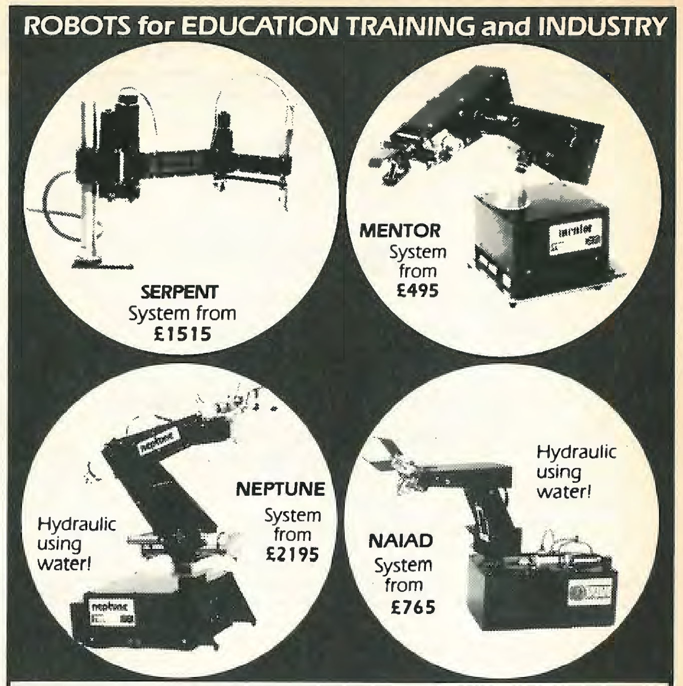

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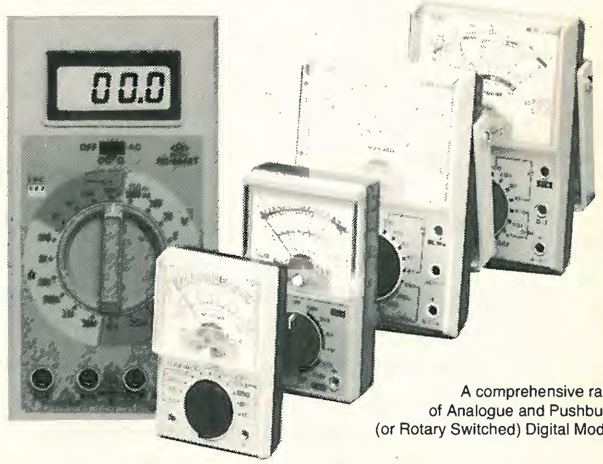

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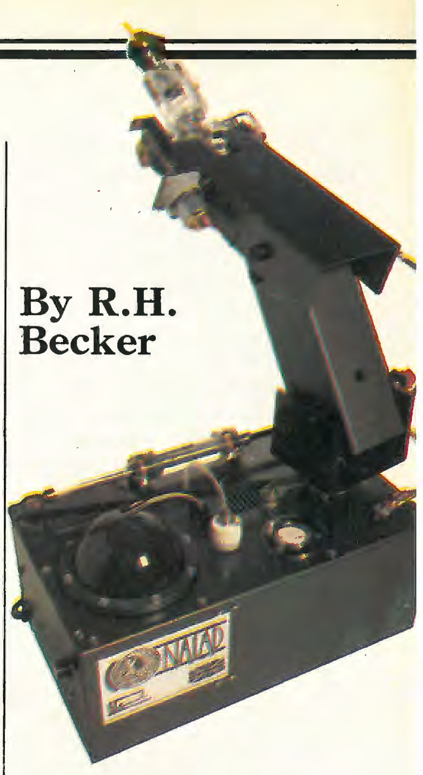


Unlike stepper motors, a servo motor will attempt to rotate continuously when there is current passed through it and the torque generated depends on that current. Servo control of an axis can be implemented with no more than a position-sensing potentiometer and an error amplifier which derives a d.c. servo motor in that direction and causes the error signal to reduce, Fig. 9. The error signal is the voltage difference between the potentiometer output and the voltage which defines the desired position at which point the error signal is zero, meaning that there is then no more current from the error amplifier to drive the motor.

Although there have recently been some high torque 'Megatorque' d.c. motors recently introduced, the torque from most motors is too small to operate an axis directly and some reduction gearing is necessary. This gearing presents a few problems. Inevitably gear teeth do not mesh perfectly and sloppiness called backlash occurs. If the position sensor is fitted to the motor the backlash becomes uncorrected error. If the sensor is fitted to the axis, and the servo system is sensing movement in the backlash, it has to cope with achieving stability whilst there is a varying torque on entering and leaving that region. Harmonic drive gearboxes, having only three moving parts, greatly reduce the backlash and are becoming widely used, but having relatively small teeth overload and slipping must be avoided. Also, harmonic drives are still single-sourced and expensive.

To fully appreciate and understand the capabilities of a machine there is nothing to beat 'hands-on' experience. However, most industrial robots are in the price range £15k to £50k and have power and accuracy far in excess of that required for training purposes. Like any other machine tool, industrial robots can be dangerous, particularly in inexperienced hands. Training, at least initially, should be carried out using small, inexpensive machines that perform the same functions as their larger counterparts, albeit at a lower specification, and be sufficiently forgiving of mistakes to be suitable for experimentation.

The Naiad was designed specifically for the purpose of safely acquiring 'hands-on' experience at low cost. Of the various configurations possible the articulated arm was selected, being the most versatile. The complexity of movement provides plenty of programming challenges and it has the most interesting mechanis.

Hydraulics, used as energy source for the most powerful industrial machines, was chosen as the main source of energy. To increase its educational value each axis operates in a different manner. There are both single-acting cylinder and double-acting cylinders, a double-ended cylinder, rubber seals, p.t.f.e. seals, and a rolling diaphragm seal. Linear motion

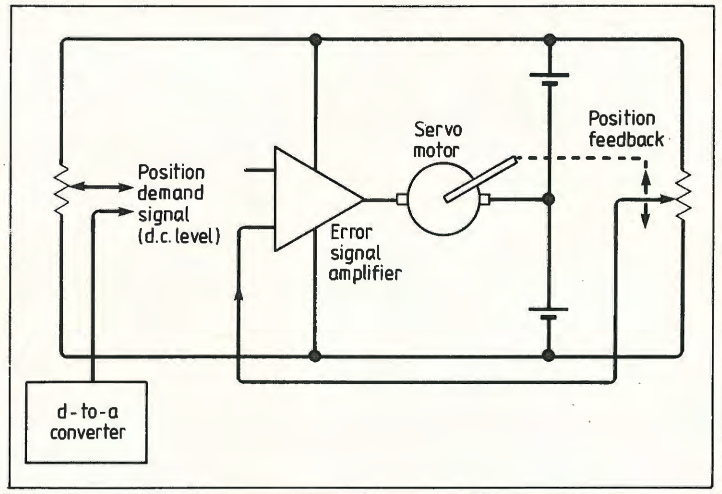


Fig. 9. This very basic control system has a d.c. motor driving the output. The mechanical output is directly coupled to the position feedback potentiometer. Signal from this potentiometer is a direct voltage level dependant on its position. The input to the system, or position demand signal, can be a similar potentiometer, digital-to-analogue converter or anything that providess a d.c. level proportional to position.

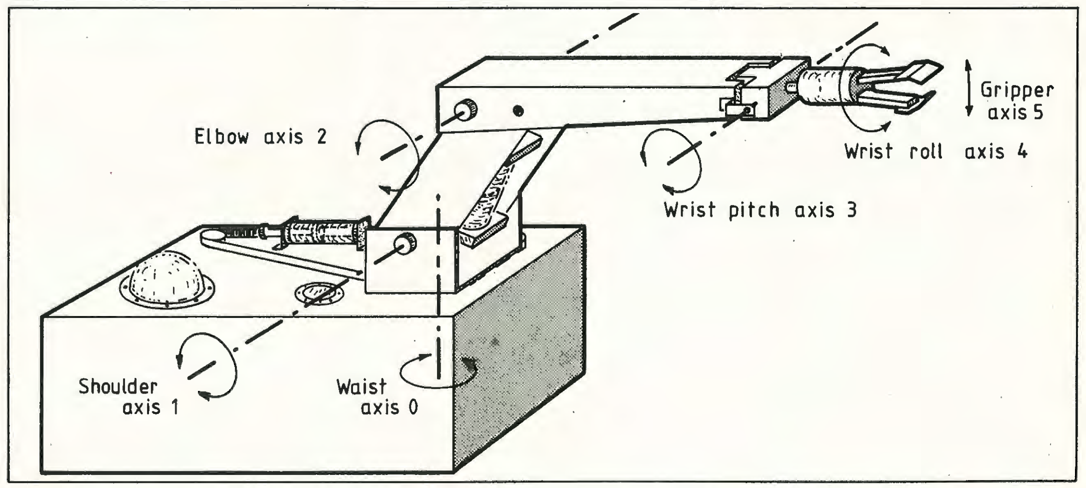


Fig. 10. Schematic of Naiad Robot showing the arrangement of the various axes. There are four hydaulic cylinders, one d.c. servo at the wrist pitch axis and the gripper can be pneumatically or hydraulically operated.

is converted to rotary motion by crank, by rack and pinion and by toothed belt with pulley. Hydraulics and pneumatics are alternative operating modes for the gripper and a d.c. servo motor with software-adjustable servo amplifier is also included. Control is by microcomputer and a simulator is included for one of its learning modes.

Experience in working with oil hydraulic systems has convinced me that for use in laboratories and education establishments a non-messy working fluid is essential and Naiad therefore uses plain tap water. To help understand the operation of a hydraulic system, many components are manufactured from Perspex, enabling workings to be clearly visible. The use of water assists in visibility and also means that the robot can be cleanly stripped down for deeper investigations or re-assembly by a different group of students.

Naiad has six axes of movement, including the gripper, with each axis built in a different way, Fig 10. Axis 0, which is the waist, uses a double-acting clyinder, Fig 11. There is a water connection at each end and a three-way valve for each end. Whilst water is pumped in at one end water from the other side of the piston is returned to the sump. On the return stroke the opposite end of the cylinder has water pumped into it whilst water from the first end is returned to sump. To each end of the piston rod is fitted one end of a toothed belt that passes round two idler pulleys and round a similarly toothed larger pulley which rotates the arm at the waist. The linear motion of the piston rod has thus been converted to the rotary motion of the arm.

Axis 1, the shoulder, uses a single-acting cylinder, Fig. 12. The weight of the arm means that gravity provides the force for the return stroke, though there is a small spring at the top of the cylinder to provide extra return force when the arm is near vertical, at which point the turning moment from gravity approaches zero. Water is controlled by two on/off valves, one connected to the sump and the other to the pump. On the upstroke the valve connected to the pump is turned on whilst the other is off. On the return stroke the opposite occurs. When both valves are off the axis is stationary.

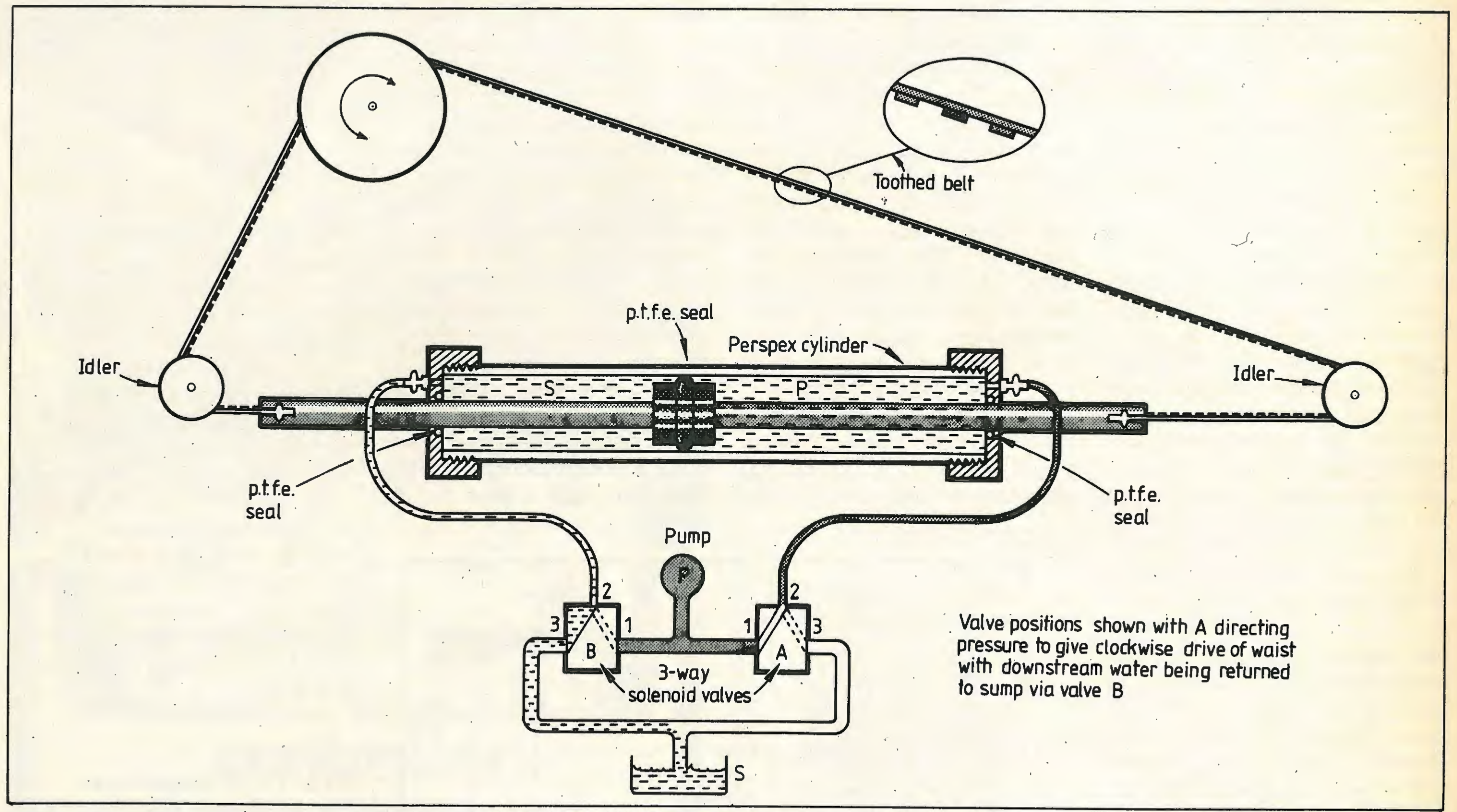
The cylinder, which uses a rolling diaphragm seal, is in two halves, clamped together to secure the diaphragm. This cylinder has a bore diameter of 32mm which with a pressure of 7 bar gives a force of about 550 newton to lift the arm, converting linear to rotary motion in crank-like manner. This operation can best be visualized by considering the arm to be stationary and the trunnion rotating. The trunnion acts as a crank of about 30mm length which then rotates through 90°, about the limit for this type of system, though it does have the desirable feature of simplicity and is widely used on robots, excavators and other hydraulic machinery.

Axis 2, the elbow, also has a single-acting cylinder, Fig. 13. Here there is less weight for returning it than on axis 1, so a longer and more powerful spring is used. The cylinder uses a conventional piston with p.t.f.e. seal. This has considerably more friction than a rolling diaphragm and the system is designed for the effects of friction to be observed and measured. There is an adjustable bypass valve and pressure gauge on the top plate of the robot to enable the pressure of the hydraulics to be finely set to facilitate the measurements on the axes.

Axis 3 is the wrist elevation and is powered by d.c. servo motor, Fig. 14. To give the required torque and angular velocity, gearing of over 1000:1 reduction is necessary. The motor comes with an integral gearbox, but would have insufficient strength to cope with the torque if its gears gave all of this reduction. External gearing in the form of a 15:1 reduction worm and wheel is therefore used together with 75:1 reduction from the motor gearbox. Worm gears mount tangentially on the worm wheel thereby turning the direction of rotation through 90°, enabling the motor/gearbox to be fitted to the side of the forearm.

Axis 4 is the wrist rotation, and here a double-ended cylinder with a rack and pinion in the centre converts the linear motion of the pistons into rotary motion, Fig. 15. The bore of this cylinder (16mm dia.) is too small for p.t.f.e. seals which require space under them for a rubber O-ring and consequently rubber piston seals are used. Rubber O-rings under the p.t.f.e. seals are necessary as the seals have little natural resilience to hold them against the cylinder wall. Rubber seals cause more friction than p.t.f.e. ones but they do seal a bit better. Like an oil hydraulic system there is a small loss of fluid past all seals except the rolling diaphragm, but, unlike oil, water soon disappears by evaporation and the robot is clean in use.

To be continued



Valve positions shown with A directing pressure to give clockwise drive of waist with downstream water being returned to sump via valve B

Fig. 11. Axis 0, the shoulder-rotation cylinder is a double acting actuator set between two idler wheels. The connecting rods, which protrude from each end of the cylinder through p.t.f.e. seals, are joined together by a toothed belt. The belt passes over the idler wheels and around a third, larger toothed wheel forming part of the axis 0 rotation assembly.

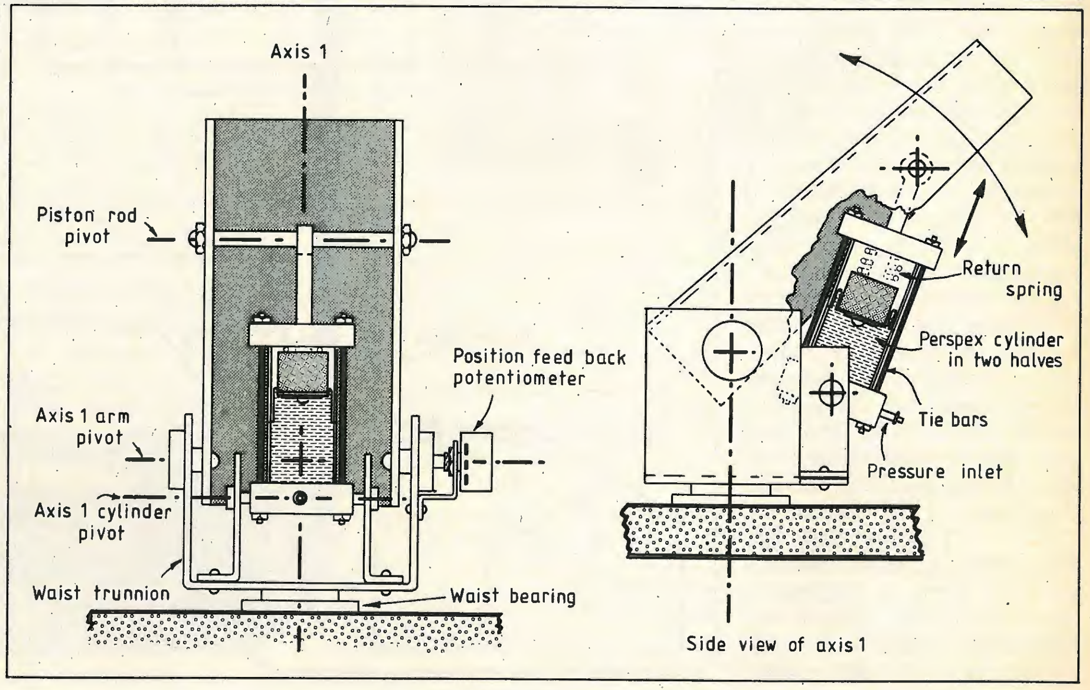


Fig. 12. Axis 1 is driven by a single acting, rolling diaphgram actuator. Pivot point at the lower end of the cylinder is actually part of the trunnion assembly. The connecting rod is linked to an axle toward the top end of axis 1 channel section. Lower end of channel section is secured to the trunnion by a delrin bush on each side; these are fixed to the channel and are free to rotate in the trunnion. The feedback potentiometer is fixed to a bracket on the trunnion and the shaft is locked into the delrin bush. Potentiometer gives position feedback of the axis 1 channel section.

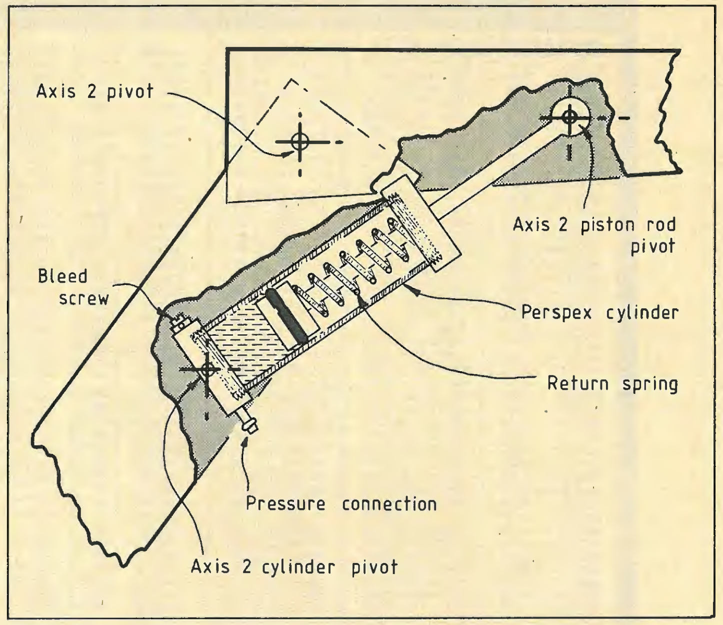


Fig. 13. Axis 2 actuator is a single-acting piston and cylinder assembly of conventional design. Water is retained within the cylinder by a p.t.f.e. band and O-ring seal around the piston.

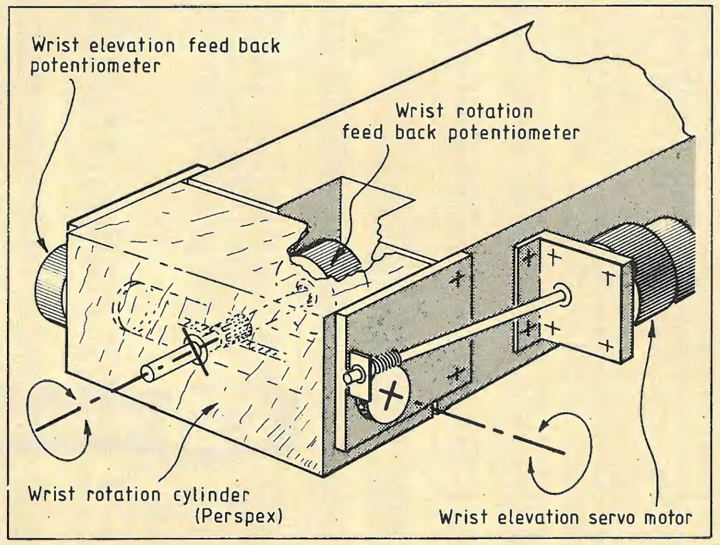

Wrist elevation feed back potentiometer
Wrist rotation feed back potentiometer
Wrist rotation cylinder (Perspex)
Wrist elevation servo motor

Fig. 14. Wrist elevation is achieved using a d.c. servo motor with integral 75:1 grearbox. On its own, this produces insufficient torque to raise the gripper carrying its rated load, and additional gearing of 15:1 is incorporated together with a 90° direction change.

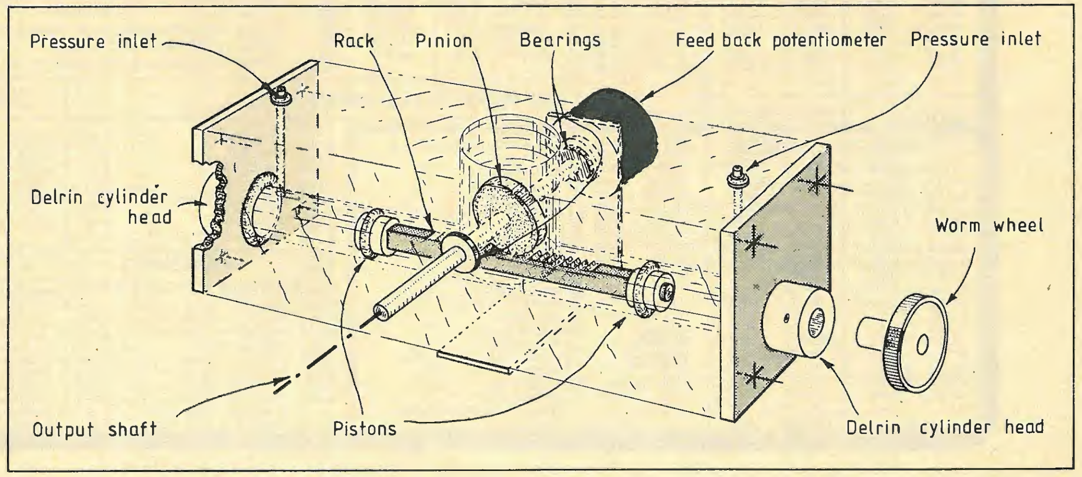


Fig. 15. Wrist rotation cylinder is a double-acting assembly formed by two pistons joined back-to-back by a length of rack in mesh with a pinnion whose central shaft protrudes from both sides of the cylinder.

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BB105B	0.30
BT151	0.79
BY126	0.10
BY127	0.11
BY133	0.15
BY164	0.45
BY176	1.20
BY179	0.63
BT182	0.55
BY184	0.35
BY199	0.40
BY206	0.14
BY208-800	0.33
BY210-800	0.33
BY223	0.90
BY298-400	0.22
BY299-800	0.22
BYX10	0.20
BYX36-150R	0.20
BYX38-600R	0.60
BXY55-600	0.30
BYX71-600	1.10
BZY95C30	0.35
CS4B	4.50
CS10B	8.45
OA47	0.09
OA90	0.05
OA91	0.06
OA95	0.06
OA202	0.10
IN21DR	5.00
IN23B	5.00
IN23C	5.00
IN23ER	5.00
IN23WE	5.00
IN4001	0.04
IN4003	0.04
IN4004	0.05
IN4005	0.05
IN4007	0.06
IN4148	0.02
IN4448	0.10
IN5401	0.12
IN5402	0.14
IN5403	0.12
IN5406	0.13
IN5407	0.16
IN5408	0.16
ITT44	0.04
ITT923	0.15
ITT2002	0.10

ZENER DIODES

BZX61Series	0.15
BZY88Series	0.10

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D13-611GM	59.00
D13-630GH	59.00
D14-150GH	75.00
D14-150GM	75.00
D14-162GH/84	59.00
D14-172GR	55.00
D14-172GV	55.00
D14-173GH	55.00
D14-173GM	53.00
D14-173GR	55.00
D14-181GH/98	65.00
D14-181GJ	55.00
D14-181GM	53.00
D14-181GM50	59.00
D14-182GH	59.00
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D14-200GA/50	85.00
D14-200GM	75.00
D14-210GH	75.00
D14-270GH/50	75.00
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D14-340KA	45.00
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D16-100GH/65	69.00
D16-100GH/67	65.00
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D16-100GH97	65.00
D18-160GH	69.00
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DB7.6	35.00
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M28-12GH	55.00
M28-13LC	49.00
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M8098	5.50
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M8162	5.50
M8163	5.50
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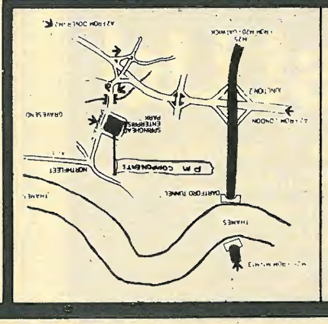
PC97	1.10
PC800	1.10
PC900	1.25
PCC84	0.40
PCC85	0.54
PCC88	0.70
PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCEB2	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	0.40
PCF200	1.80
PCF201	1.80
PCF800	0.40
PCF801	1.35
PCF802	0.60
PCF805	1.25
PCF806	1.00
PCF808	1.25
PCH200	1.50
PCL82	0.85
PCL83	2.50
PLC84	0.75
PCL85	0.80
PLC86	0.85
PLC800	0.80
PLC805	0.90
PD500	3.50
PD510	3.65
PE1-100	69.00
PEN25	2.00
PEN40DD	2.50
PEN45	3.00
PEN45DD	3.00
PNE46	2.00
PE06-4oN	42.00
PFL200	0.95
PL21	2.50
PL36	0.95
PL38	1.50
PL81	0.72
PL81A	0.72
PL82	0.60
PL83	0.52
PL84	0.78
PL88	1.00
PL95	1.75
PL302	1.00
PL345	12.50
PL500	1.10
PL504	1.15
PL508	1.75
PL509	4.85
PL519	4.95
PL802	5.95
PL802T	3.50
PL820	2.95
PL5557	29.50
PY32	0.60
PY33	0.50
PY81	0.70
PY82	o.70
PY83	0.70
PY88	0.65
PY500A	1.95
PY800	0.79
PY801	0.79
QB3-300	54.95
QB3-1750	139.50
QB5-3500	495.00
QE03-10	4.95
QE08-200	145.00
QF40	65.00
QP25	1.00
QQE02-5	19.50
QQE03-12	7.95
QE03-20	35.00
QQE06-40	45.00
QQV02-6	19.50
QQV03-10	5.50
QQV03-10 Mullard	15.00
QQV03-20	25.00
QQV03-20B	32.00
QQV06-40A	27.50
QQV07-50	63.50
QQZ03-20	42.50
QS75/20	1.50
QS75/40	3.00
QS92/10	5.00
QS95/10	4.85
QS108/45	4.00
QS150/15	6.95
QS150/30	1.15
QS150/45	7.00
QS1200	3.95
QS1202	3.95
QS1203	4.15
QS1205	3.95
QS1206	1.05
QS1207	0.90
QS1208	0.90
QS1209	3.15
QS1210	1.50
QS1211	1.50
QS1212	3.20
QS1213	5.00
QS1215	2.10
QS1218	5.00
QU37	9.50
QV03-12	4.95
QV05-25	1.75
QV06-20	29.50
QV08-100	145.00
QV2-2500	45.00
QY3-125	65.00
QY4-250	70.00
QY4-400	76.00
R10	4.00
R16	12.00
R17	1.50
R18	2.50
R19	2.50
R20	1.20
R1169	55.00
RG1-125	4.95
RG1-240A	14.50
RG3-250A	3.50
RG3-1250A	35.00
RK2K25	62.50
RK-20A	12.00
RL16	1.50
RPL16	12.00
RPY13	2.50
RPY43	2.50
RPY82	2.50
RR3-250	15.00
RR3-1250	35.00
RS613	45.00
RS685	54.95
RSS688	52.15
S6F17	5.95
S6F33	28.95
S11E12	38.00
A30/2K	12.00
S104/1K	10.00
S109/1K	15.00
S130	5.59
S130P	5.95
SC1/800	5.00
SC1/1100	6.00
SC1/1200	5.00
SC1/1300	6.00
SC1/200	9.00
SD6000M	45.00
SP41	5.00
SP42	3.00
SP4B	4.95
SS501	35.00
ST11	1.50
STV280/40	11.95
STV280/80	19.95
SU42	4.95
TB2.5/300	85.00
TB2-300	45.00
TB3-2000	395.00
TBL-2-300	275.00
TD1-100A	25.00
TD03-10F	35.00
TD3-12	4.00
TDD4	5.50
TP25	1.50
TSP4	7.00
TT11	1.50
TT21	45.00
TT22	45.00
TT100	57.00
TTR-31MR	65.00
TY2-125A	85.00
TY4.400	85.00
TY8-600W	365.00
TYS2/250	375.00
U18-20	2.75
U19	11.95
U24	2.00
U25	0.90
U26	0.90
U37	9.00
U41	6.95
U50	2.00
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	2.95
UBC81	1.50
UBF89	0.60
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	2.50
UCH42	2.50
UCH81	0.65
UCL82	1.75
UCL83	2.50
UF41	1.15
UF42	1.15
UF80	1.75
UF85	1.20
UF89	2.50
UL44	3.50
UL85	0.85
UU5	3.50
UU7	8.00
UU8	9.00
UY41	3.50
UY85	0.70
V235A/1K	250.00
V238A/1K	295.00
V240C/1K	225.00
V241C/1K	195.00
C2464A/2K	315.00
V339	3.50
V453	12.00
VLS631	10.95
VP4B	4.50
VP133	2.00
VR75/30	3.00
VR101	2.00
V105/30	1.50
VR150/30	1.15
VT52	2.50
VU29	4.50
VU39	1.50
W21	4.50
W77	5.00
W729	1.00
W739	1.50
X24	4.50
X66/X65	4.95
X76M	1.95
XC24	1.50
XC25	0.50
XFW47	1.50
XFW50	1.50
XG2-6400	135.00
XG5-500	22.50
XI1-5V	1.50
XL628FT	7.50
XNP12	2.50
XR1-1600A	49.50
XR1-3200A	79.50
XR1-6400A	99.50
Y502	25.00
Y65	6.95
Y602	12.00
YD1100	75.00
YJ1060	265.00
YL1020	29.00
YL1070	195.00
YL1071	195.00
YL1290	65.00
Z77	1.20
Z302C	12.00
Z359	9.00
Z505S	15.00
Z520M	4.00
Z521M	8.00
Z700U	3.00
Z749	0.60
Z759	19.85
Z800U	3.00
Z803U	18.95
ZA1000	12.50
ZA1001	1.50
ZA1002	1.50
ZC1040	8.00
ZM1005	8.00
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1082	9.00
ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
ZM1612	3.00
1A3	4.50
1AC6	1.20
1B3GT	1.95
1B22	10.00
1B24	14.95
1B35A	29.50
1C1	2.50
1C5GT	2.50
1FD1	2.50
1G3GT	2.50
1J3GT	2.50
1N2	4.50
1N5GT	2.50
1P28	25.00
1T4	0.70
1U5	1.00
1X2B	1.40
1Z2	8.95
2B7	1.50
2B22	69.50
2C39A	32.50
2C39BA	39.50
2C40	37.00
2C42	29.50
2C51	0.75
2C53	32.00
2CY5	1.50
2D21	1.50
2D21W	2.50
2E26	7.95
2J42	93.00
2K25	27.50
2K25 Raytheon	75.00
2K26	95.00
3A/107B	12.00
3A/108A	9.00
3A/109B	11.00
3A/110B	12.00
3A/141K	11.50
3A/147J	7.50
3A/167M	10.00
3A2	3.95
3A3A	3.95
3A4	1.10
3AL5	0.95
3AT2	3.35
3B2	3.00
3B4	7.00
3B7	4.50
3B24	10.00
3B26	24.00
3B28	12.00
3BZ6	1.50
3C4	1.00
3C23	19.00
3C45	24.00
3CB6	1.50
3CN3A	2.50
3CS6	0.95
3CX3	2.50
3CY5	1.50
3D6	4.50
3D21A	29.50
3E22	49.50
3EH7	1.95
3EJ7	1.95
3W4GT	2.50
485518	115.00
4-65A	59.00
4687A	9.50
4-125A	72.50
4-250A	79.50
4-400A	87.50
4832	35.00
4BQ7A	1.75
4BZ6	1.95
4C27	25.00
4C28	25.00
4CB6	1.95
4CX250B	49.00
4CX250B EIMAC	59.50
4CX250BM	75.00
4CX250K EIMAC	95.00
4CX125C EIMAC	125.00
4CX350A	95.00
4CX350F	79.50
4XC1500B	398.50
4GS7	2.25
4GV7	2.25
4J52	75.00
4JC6A	2.95
4X150A	35.00
5A/102D	9.50
5A152M	9.00
5A163K	10.00
5A170K	6.25
5A-180M	9.00
5A-206K	10.00
5AMB	2.15
5ANB	1.20
5AR4	2.00
5AU4	1.50
5B.110M	10.00
5B-254M	14.50
5B-255M	19.50
5B-256M	9.00
5B-257M	9.00
5B-258M	14.50
5C22	125.00
5J180E	1895.00
5R4GB	3.50
5R4GY	3.50
5T4	5.95
5U4G	2.50
5U4GB	2.50
5V4G	1.25
5Y3GT	1.95
5Z4GT	0.85
6/30L2	0.70
6A/203K	9.00
6A7	4.95
6A8G	1.50
6AC7	2.00
6AF4A	2.50
6AG5	1.50
6AG7	1.95
6AH6	2.50
6AJ4	2.00
6AJ7	2.00
6AK5	1.50
6AK6	2.50
6AL5	0.60
6AM4	3.25
6AM5	6.00
6AM6	1.50
6AN5	2.65
6AN8A	2.65
6AQ5	1.75
6AQ8	0.85
6AR5	5.95
6AR8	3.95
6AS5	1.50
6AS6	2.50
6AS7G	4.50
6AT6	0.75
6AT8	1.75
6AU4	2.00
6AU6	0.95
6AV6	0.75
6AW8A	2.50
6AZ8	5.95
6B7	2.80
6B8G	1.50
6BA6	0.95
6BA7	4.50
6BA8A	3.50
6BC8	1.00
6BD4	1.50
6BD6	2.50
6BE6	0.72
6BG6G	3.00
6BH6	1.95
6BH8	1.50
6BJ6	1.20
6BK4	4.00
6BK7A	1.95
6BL8	1.15
6BM8	0.58
6BN4	1.65
6BN6	1.65
6BN7	4.50
6BN8	3.95
6BQ5	0.75
6BQ5	0.75
6BQ7A	0.72
6BL7GTA	3.95
6BR5	0.70
6BR7	4.95
6BR8	2.15
6BR8A	2.15
6BS7	5.50
6BW4	1.50
6BW6	5.35
6BW7	1.50
6BW8	4.00
6BX6	0.48
6BX7GT	3.50
6BZ6	2.50
6BZ7	2.95
6C4	1.10
6C5	1.95
6C6	2.50
6C8G	1.50
6C11	2.50
6C18	2.50
6CA4	4.95
6CA7	3.50
6CB5	3.95
6CB6	1.95
6CD6GA	4.50
6CF6	1.50
6CG7	2.25
6CH6	6.95
6CL3	3.95
6CL6	3.25
6CL8A	1.50
6CM5	1.60
6CM7	2.95
6CS6	0.75
6CW4	6.50
6CY5	1.00
6D6	2.50
6DC6	2.35
6DJ8	0.95
6DK6	1.15
6DQ5	5.95
6DQ6B	2.50
6DT6A	1.50
6DW4	2.15
6EA4	4.95
6EA7	2.50
6EA8	2.50
6EB8	1.75
6EM5	2.50
6EM7	2.50
6EU7	1.95
6EU8	1.75
6EV7	2.95
6EW6	1.50
6EW7	4.50
6F1	2.00
6F5	4.95
6F6	2.50
6F6G	2.00
6F7	5.50
6F12	1.50
6F13	3.00
6F14	1.00
6F17	2.75
6F21	2.50
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F32	1.25
6F33	17.00
6FG5	1.95
6FQ7	2.95
6G6G	5.50
6GH8A	0.80
6GK5	1.50
6GK6	1.95
6GS7	2.15
6GV7	2.50
6GW6	2.50
6H1	9.50
6H3N	1.10
6H6	1.95
6H6GT	1.95
6HF5	5.50
6HF8	2.50
6HS6	4.95
6J4	2.15
6J4WA	3.15
6J5	2.50
6J6	2.00
6JB6A	3.95
6JE6C	4.95
6JU8	2.50
6JS6C	4.95
6J7G	4.15
6K7G	2.00
6K8G	3.00
6KD6	5.50
6KM8	2.50
6KT8	2.95
6L1	2.50
6L15	3.15
6L19	3.95
6L6GC	2.95
6L6GC(GE)	4.50
6L6GT	1.95
6LD20	1.15
6LF6	7.50
6LJ8	2.50
6LQ6	4.95
6N7	2.50
6N7GT	2.50
6P15	1.50
6P25	4.00
6P26	4.00
6P28	2.00
6Q7	1.75
6Q7GT	1.20
6R7G	3.15
6S4A	1.50
6SA7GT	1.35
6SC7	1.50
6SG7	1.35
6SH7	1.35
6SJ7GT	1.20
6SK7	1.35
6SK7GT	1.35
6SL7GT	0.85
6SN7GT	1.35
7SQ7	1.35
6SS7	1.95
6U4GT	1.75
6U8	1.15
6U8A	1.50
6V6GT	1.50
6X2N	1.00
6X4	1.50
6X5GT	1.00
6X5GTY	1.00
6X8B	2.25
7A6	4.50
7A7	2.00
7AD7	1.75
7B6	3.50
7B7	2.50
7C5	3.50
7C6	2.50
7E7	2.50
7H7	3.50
7AU7	1.50
7J7	5.50
7Y4	2.50
8B8	2.50
8B10	2.50
8BQ5	1.95
8FQ7	1.95
10D2	1.25
10DE7	2.50
10F1	0.75
10GK6	1.95
10P14	2.50
10P18	0.78
10LD12	0.65
11E3	55.00
12A6	3.95
12AD6	1.50
12AG8	1.50
12AL5	1.00
12AT6	0.95
12AT7	1.15
12AT7WA	2.50
12AU6	1.50
12AI7	0.65
12AV6	1.95
12AV7	2.50
12AX4GT	1.00
12AX7	0.65
12AX7WA	2.50
12AY7	3.95
12AZ7A	1.95
12B4A	4.50
12BA6	1.50
12BE6	1.95
12BH7A	2.50
12BL6	1.75
12BY7A	2.75
12CA5	1.95
12CX6	1.20
12DQ6B	3.50
12DW4A	3.50
12DW7	2.50
12E1	17.95
12E14	38.00
12GN7	3.95
12HG7	4.50
12HG7A	4.50
12J7GT	3.50
12K5	1.95
12K7GT	1.50
12K8	1.95
12SA7GT	1.95
12SG7	4.75
12SH7	1.95
12SK7	1.95
12SJ7	1.50
12SQ7GT	1.95
12SR7	2.50
12SQ7GT	1.50
13D3	3.20
13D7	3.20
13D9	3.20
13DE7	2.50
13DR7	2.95
13E1	145.00
13EM7	3.50
14S7	1.95
17DW4A	2.95
17EW8	0.95
17JZ8	4.50
18D3	6.00
19AQ5	3.50
19AU4GT	2.50
19G3	17.00
19H5	33.50
19Q6	9.00
20A2	10.50
20D1	0.70
20LF6	3.50
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.95
20P5	1.15
21LU8	2.50
24B1	39.50
25L6GT	1.75
25BQ6	1.75
29C1	19.50
29KQ6	6.50
30C17	0.40
30C18	1.48
3F5	0.95
30FL1	1.00
30FL2	1.35
30FL12	0.95
30FL13	1.10
30FL14	1.25
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30PL1	2.50
30PL13	0.60
30PL14	1.75
31JS6C	5.50
33A/158M	19.50
35A5	4.50
35L6GT	2.00
35W4	0.70
35Z3	1.85
38HE7	4.50
40KD6	5.50
42	6.95
47	6.00
50A5	1.50
50C5	0.95
50CD6G	1.15
50EH5	1.50
50JY6	2.95
52KU	2.00
53CG	15.00
61SPT	4.50
75B1	3.50
75C1	2.50
83	8.50
84	3.00
85A1	6.50
85A2	1.50
90AV	10.00
90C1	2.70
90CG	13.50
90CV	12.50
91AG	9.00
92AG	19.50
92AV	12.50
95A1	6.50
108C1	1.50
150B2	6.95
150C2	1.50
150C4	2.15
155UG	25.00
185BT	1.50
211	33.50
274A	15.00
307	5.00
328A	15.00
388A	17.50
425A5	8.00
431U	4.50
572B	65.00
705A	8.00
708A	8.00
715C	45.00
724A	275.00
803	14.95
805	39.00
807	1.95
810	85.00
811A	15.00
812A	35.00
813	23.50
829B	14.50
833A	95.00
866A	4.50
872A	27.50
873	60.00
884	5.50
930	9.95
931A	13.95
954	1.00
955	1.00
958A	1.00
1299A	0.60
1619	2.50
1625	3.00
1626	3.00
2050W	4.50
2050	3.95
3534	4.00
404A	10.95
927	15.00
1927	25.00
4212E	250.00
4313C	4.00
4328D	9.00
5642	9.50
5651	2.50
5654	1.95
5663	1.95
5670	3.25
5672	4.50
5687	4.50
5692	3.50
5696	3.50
5704	3.50
5718	6.15
5725	2.50
5726	1.50
5727	1.95
5749	2.50
5750	1.85
5751	2.95
5763	4.95
5814A	3.25
5829WA	6.50
5636	5.50
5678	7.50
5840	3.50
5842	11.00
5847	10.95
5879	8.50
5886	13.95
5894	39.50
5899	4.50
5963	1.75
5965	2.25
6005	1.85
6012	16.00
6021	3.65
6057	2.50
6058	3.95
6059	3.75
6060	2.25
6062	4.50
6063	2.00
6064	3.25
6067	1.95
6072	4.20
6080	8.50
6080WA	9.50
6132	10.00
6136	2.50
6146B	9.50
6157	2.50
6158	3.20
6201	6.45
6205	6.95
6211	2.50
6267	4.50
6350	3.50
6360	4.50
6386	14.50
6545	8.50
6550	10.95
6688	6.50
6870	11.50
6887	9.50
68838	9.95
6973	5.95
7025	2.50
7027A	4.50
7032	2.00
7059	2.50
7167	3.95
7189	3.50
7193	7.50
799	7.50
7247	2.95
7360	13.50
7462	15.00
7475	5.00
7486	125.00
7527	85.00
7551	6.95
7558	9.45
7586	15.00
7587	29.50
7591A	4.95
7609	47.00
7733	5.50
7788	25.00
7868	3.95
8012	15.00



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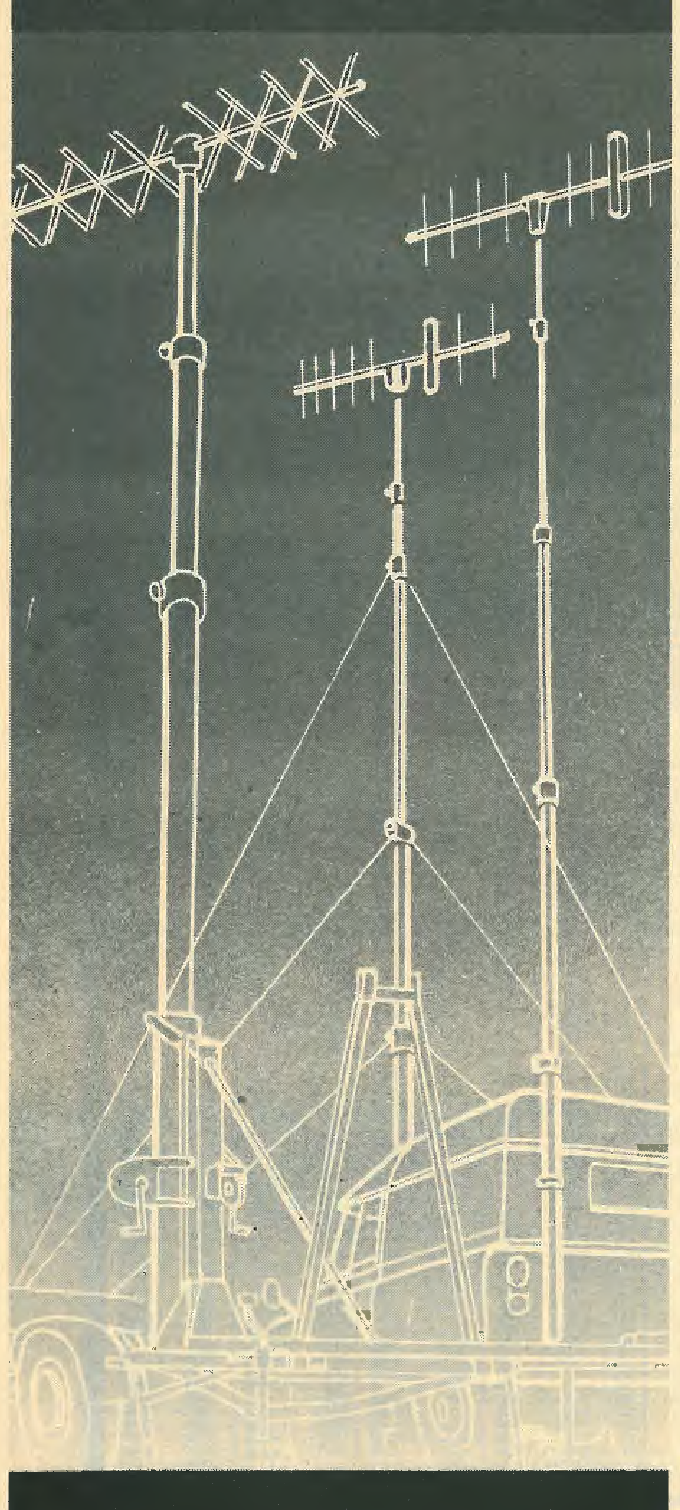

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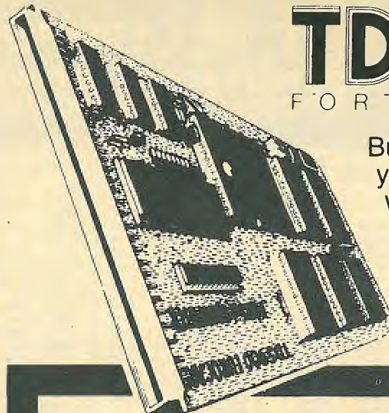

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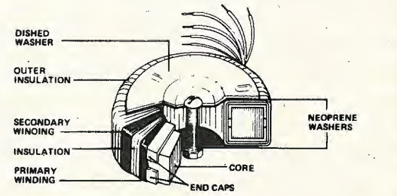

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15VA Regulation 19% 62 x 34 (See diagram) 0.35 Kgs Mounting bolt M4 x 12	03010	6+6	1.25
	03011	9+9	0.83
	03012	12+12	0.63
	03013	15+15	0.50
	03014	18+18	0.42
	03015	22+22	0.34
	03016	25+25	0.30
	03017	30+30	0.25
30VA Regulation 18% Size A B C 70 35 37 0,45 Kgs Mounting bolt M5 x 50	13010	6+6	2.50
	13011	9+9	1.66
	13012	12+12	1.25
	13013	15+15	1.00
	13014	18+18	0.83
	13015	22+22	0.68
	13016	25+25	0.60
	13017	30+30	0.50
50VA Regulation 13% Size A B C 80 40 43 0,9 Kgs Mounting bolt M5 x 50	23010	6+6	4.16
	23011	9+9	2.77
	23012	12+12	2.08
	23013	15+15	1.66
	23014	18+18	1.38
	23015	22+22	1.13
	23016	25+25	1.00
	23017	30+30	0.83
	23028	110	0.45
	23029	220	0.22
	23030	240	0.20
80VA Regulation 12% Size A B C 95 40 43 1,0 Kgs Mounting bolt M5 x 50	33010	6+6	6.66
	33011	9+9	4.44
	33012	12+12	3.33
	33013	15+15	2.66
	33014	18+18	2.22
	33015	22+22	1.81
	33016	25+25	1.60
	33017	30+30	1.33
	33028	110	0.72
	33029	220	0.36
	33030	240	0.33
120VA Regulation 11% Size A B C 95 45 50 1.2 Kgs Mounting bolt M5 x 50	43010	6+6	10.00
	43011	9+9	6.66
	43012	12+12	5.00
	43013	15+15	4.00
	43014	18+18	3.33
	43015	22+22	2.72
	43016	25+25	2.40
	43017	30+30	2.00
	43018	35+35	1.71
	43028	110	1.09
	43029	220	0.54
	43030	240	0.50

TYPE	SERIES NO.	SEC. VOLTS	R.M.S. CURRE NT
160VA Regulation 8% Size A B C 110 45 50 1.8 Kgs Mounting bolt M5 x 50	53011	9+9	8.89
	53012	12+12	6.66
	53013	15+15	5.33
	53014	18+18	4.44
	53015	22+22	3.63
	53016	25+25	3.20
	53017	30+30	2.66
	53018	35+35	2.28
	53026	40+40	2.00
	53028	110	1.45
	53029	220	0.72
	53030	240	0.66
225VA Regulation 7% Size A B C 110 50 55 2.2 Kgs Mounting bolt M5 x 60	63012	12+12	9.38
	63013	15+15	7.50
	63014	18+18	6.25
	63015	22+22	5.11
	63016	25+25	4.50
	63017	30+30	3.75
	63018	35+35	3.21
	63026	40+40	2.81
	63025	45+45	2.50
	63033	50+50	2.25
	63028	110	2.04
	63029	220	1.02
	63030	240	0.93
300VA Regulation 6% Size A B C 110 57 62 2.6 Kgs Mounting bolt M5 x 60	73013	15+15	10.00
	73014	18+18	8.33
	73015	22+22	6.82
	73016	25+25	6.00
	73017	30+30	5.00
	73018	35+35	4.28
	73026	40+40	3.75
	73025	45+45	3.33
	73033	50+50	3.00
	73028	110	2.72
	73029	220	1.36
	73030	240	1.25
500VA Regulation 5% Size A B C 135 60 65 4.0 Kgs Mounting bolt M8 x 70	83016	25+25	10.00
	83017	30+30	8.33
	83018	35+35	7.14
	83026	40+40	6.25
	83025	45+45	5.55
	83033	50+50	5.00
	83042	55+55	4.54
	83028	110	4.54
	83029	220	2.27
	83030	240	2.08

TYPE	SERIES NO.	SEC. VOLTS	R.M.S. CURRENT
625VA Regulation 4% Size A B C 140 70 75 5.0 Kgs Mounting bolt M8 x 90	93017	30+30	10.41
	93018	35+35	8.92
	93026	40+40	7.81
	93025	45+45	6.94
	93033	50+50	6.25
	93042	55+55	5.68
	93028	110	5.68
	93029	220	2.84
	93030	240	2.60

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CIRCLE 69 FOR FURTHER DETAILS.

Receiving satellite tv now

By D.J. Standen

Not everyone is clear about satellite tv. Is it only for the future? What is receivable now? How much does it cost? And is it legal?

Satellite television in the band 10.9-11.7GHz has been called 'Europe's best kept secret'. There is very little published on the subject, so this article aims to answer some of the many questions asked and provide an insight into this new and fast-expanding field.

Currently, transmissions are available from four satellites, ECS1, ECS2, Gorizont and Intelsat 5 (27.5°W). Between them they provide at least 18 different stations. ECS3 would have provided several more, but due to the failure of the launch we will have to wait before the replacement satellite is launched. It is quite legal to receive these transmissions and a licence is available on application to the DTI, the fee is £10 for an indefinite period.

11GHz band

The 10.9 to 11.7GHz band is designated as a Broadcast Service Satellite band though the transmissions are at a much lower power level than that intended for direct broadcast satellites. The original purpose of the transmissions was to provide feeds to the cable head-end of networks such as Swindon Cable. Signals are received at the main antenna site by large (4 to 5m) dishes and after demodulation distributed via cable to houses connected to the monthly subscription service.

Until recently it was illegal to receive these transmissions without a Test & Development licence, only granted to companies involved in research or antenna manufacture. At the time that the power levels of transmissions in the 11GHz band were decided it was considered financially impossible for the public to receive these broadcasts, as the level of technology at the time required a very large dish at considerable cost. But technology does not stand still and with the low-noise amplifiers of today the dish size has been reduced to a point where a small dish in a suburban garden will give very high quality reception.

The size of dish required for above-threshold reception depends on the receiving location. Reference to footprint charts, which give the signal strength contours, a signal strength of -118dBW/m^2 can be achieved in the centre of the spotbeam. The beam patterns for ECS1 and Intelsat indicate that reception is adequate with a 1.6m dish, and signals 3dB down on the spot centre will require a 2.4m dish, and 6dB down a 3.2m dish. Reception becomes more expensive the further from the UK one gets: in southern Spain a 3m dish is required for ECS.

Polar mount rear support structure can be fitted with motor and remotely controlled from the tv set or simply hand operated with lead-screw to reduce cost.

Antennas

In the USA, which has had satellite tv for some time, the wire mesh type of parabolic dish is quite common. This is suitable where reception takes place at C-band (3.7-4.2GHz) as in the USA, but this type of dish will not function on the 11GHz band as mesh size must be no larger than 1/10th wavelength.

In the UK a solid aluminium parabolic dish is required to be accurate to ±1.5mm. Three types of mount are used: fixed, 'az/el' and polar. The fixed mount is usually of A-frame construction and is intended for fixed use onto a single satellite, or mounted on a trailer for demonstration purposes, when it can be quickly set to any satellite. The az/el mount allows the dish to be moved in both azimuth and elevation, and each time a different satellite is required the dish must be realigned. The polar mount is the most difficult to set initially but the easiest to use. Once set, it will always track the geostationary arc; a manual-only version requires a tracking handle to be turned to scan the correct arc. This type of dish can be motorized with a single motor having a control unit alongside the tv receiver. For UK reception a dish with a gain of 42dB minimum at 11GHz is required.

Low-noise block downconverter and feed horn

The microwave electronics is situated at the focal point of the dish in most domestic applications. With dishes of F/D ratio between 0.35 & 0.42 the feed is commonly of the scalar horn type, consisting of concentric rings with a circular waveguide matched to the WR75/WG17 waveguide normally used in these low-noise blocks (l.n.bs). Energy focused onto the horn is fed by circular waveguide to a probe feeding the first GaAs f.e.t. amplifier. A two-stage r.f. amplifier is normally used prior to a mixer with a dielectric resonator oscillator. The i.f. output of 950 to 1750MHz is amplified within the l.n.b. giving an overall gain of around 55dB.

Amplifier noise figures have been steadily reducing recently and this is the main reason why a smaller dish than first anticipated can be used. A 2.9dB noise figure is easily achieved and 2.5dB is common; higher grade l.n.bs can be obtained with figures as low as 1.9dB. Power to the unit is by coaxial cable which should be of very low loss in the range of 1 to 2GHz.

The demodulator

Coaxial cable from the low-noise block is taken to an indoor unit normally situated on top of the television receiver.

Many different demodulators are available for this prupose spanning a wide price range, but the principle of operation is mainly the same. The i.f. of 950 to 1750MHz is mixed down to a second or third i.f. and being an f.m. signal is demodulated by either phase-locked loop or quadrature demodulator. After amplification, de-emphasis and clamping, the video signal is available as a 1V pk-pk signal and in some cases is applied to a modulator to give a u.h.f. channel 36 signal for connection to the tv set. Sub-carriers are separately demodulated and as satellite broadcasts use various audio subcarriers (4 to 8MHz) it is necessary to be able to tune these from the front panel.

The nature of the satellite transmissions has made the life of the designer somewhat difficult. Intended for cable networks where a 'dedicated' demodulator is assigned to each channel, the variety of audio and video formats is of little tance. But for domestic use all channels will need to be receivable by the same unit. To produce a multi-standard demodulator would be too expensive for most people so some sort of compromise is usually inevitable.

SATELLITE TRANSPONDER ALLOCATIONS

Satellite	Station	Freq. (GHz)	Audio (MHz)	Language	Material	Standard	Bandwitdh	Beam
ESC1	RAI	10.991	6.6	Italian	National 1 programme	PAL	36	West
	SAT 3	11.056	SIS	German	Films & news	PAL	36	East
	EUROPA	11.175	6.6	Eng/Dutch	General interest	PAL	30	West
	TV5	11.472	6.65	French	Best of French TV	SECAM	36	West
	CATALAN NEWS	11.472	6.65	Catalan	News feed daily	PAL	36	West
	EBNET	11.512	6.65	Various	Religious channel	PAL	36	West
	WORLDNET	11.512	6.65	English	US Information Agency	PAL	36	West
	SKY	11.650	6.65	English	General & also stereo	PAL	27	West
	TELECLUB	10.987	6.5	German	Films	PAL	36	West
	FILMNET	11.140	6.65	Eng/Dutch	Films	PAL	30	West
	WPN	11.140	6.65	Eng/French	Documentary	PAL	30	West
	SAT 1	11.507	SIS	German	Films, News	PAL	36	West
	VOA	11.507	7.00	English	Pop music & news (audio)	NONE	—	West
	MUSIC BOX	11.674	6.65, 7.02, 7.2	English	Pop Video Channel	PAL	36	West
INTELSAT F10 (27.5°W)	PREMIERE	11.015	6.6	English	Films	PAL	30	West
	CHILDREN'S CH	11.015	6.6	English	Children's programmes	PAL	30	West
	SCREEN SPORT	11.135	6.6	English	Many different sports	PAL	30	West
	MIRRORVISION	11.175	6.6	English	Films	PAL	30	West
	CNN	11.155	6.6	English	USA 24h NEWS	PAL	36	East
INTELSAT VA (18°W)	BBC	11.150	6.65	English	Very rare. News feeds	PAL		West
GORIZONT (14°W)	USSR	11.512	7.0	Russian	Rare. Prog 1 tests	SECAM		
ECS 2	NORWAY	11.676	None	Norse	C-MAC system	C-MAC		West
	EBU	11.142	SIS	Various	News feeds & sport	PAL		West
	EBU	11.176	SIS	Various	News feeds & sport	PAL		West

SIS — Sound in sync, PCM2 system. EBU — European Broadcasting Union transmitting material in the language of the originating member.
NOTE: It is not possible to receive either audio or clear video from SIS or C-Mac Transmissions with a normal PAL Rx.

Typical scalar horn feed with polarization boss that allows l.n.b. to rotate polarization by 90° enabling reception of both x and y polarized transmissions.

Market potential

To achieve a large-scale market sales must be made to the public, but before that happens people need to be made aware of the entertainment possibilities available. This will be done by television retailers moving into this new field with a demonstration unit in their shops. Having just spent a week at a recent exhibition on behalf of Connexions Satellite Systems with a complete satellite system on the stand, it appears that a great many computer dealers are keen to move into a new product and can see the potential offered by satellite television. And public awareness will be greatly increased as hotels and apartment blocks establish master antenna systems. Universities are finding it an excellent medium for language studies.

Although dish size and cost increases outside the UK there are many ex-patriat residents in France, Spain and Portugal for whom reception of English language programmes is worth the high purchase price — around £3000 duty paid.

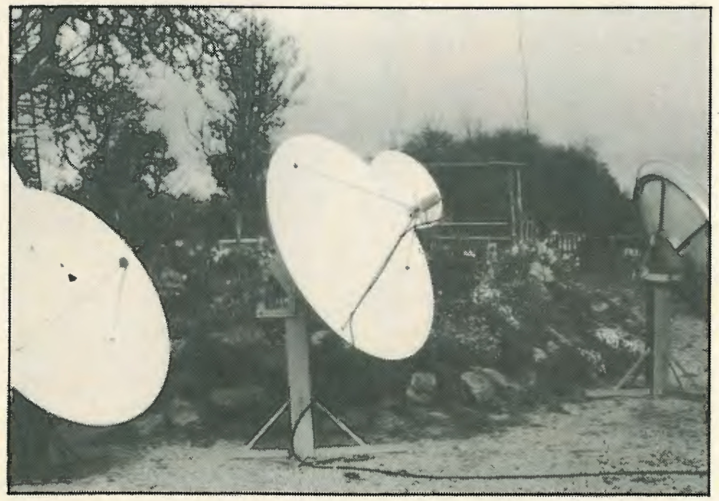
Although current satellites offer a variety of programme material, for those less well off the future looks bright. Apart from French and German satellite broadcasting it is likely that ITV will run its Superchannel Europe through the French high power d.b.s. satellite TDF1 next year. Reception in Spain should be possible on a 1m dish with a basic system at around £500.

Programme material

On a satellite by satellite basis it may be of interest to readers to see what is available from a home system. **Intelsat 5** (27.5°W) currently has four operational transponders. From 0800 to 1500h the Children's Channel transmits programmes for 4 to 11-year-olds (cartoons, stories, things to make and do). After 1500h this transponder becomes Premier, a Thorn EMI channel, and runs films about every two hours till the

North East Satellite Systems spun aluminium dish antenna with low-noise block measures 1.6m diameter — the smallest dish size that can be used on Intelsat transponders with current power levels for film and sports channels up to the Scottish border.

John Standen owns North East Satellite Systems of Cropton, North Yorkshire, a company dedicated to making microwave technology affordable. He is also technical director of Connexions Satellite Systems Ltd.



small hours of the morning (no advertising).

Screen Sport starts at 1700h (till 2300) with material devoted only to sport, though the variety is wide — American baseball and football, aerobatics, parakiting, shark fishing, with several hours per week devoted to rally & motor racing. Mirrorvision, owned by Robert Maxwell, is another film channel from 1600 till midnight, with a new film every two hours.

CNN from the USA runs a 24-hour news channel up-linked from Virginia, transcoded to PAL and linked via Intelsat to Europe.

Also awaited for in the autumn are a magazine channel (Lifestyle), the Arts Channel devoted to theatre & classical music, and a few others. **ECS1**, otherwise known as Eutelsat F1, carries several foreign broadcasts. RAI from Italy transmits its national programme daily from morning till late at night, in Italian of course. Teleclub transmits from Switzerland in German; this is a film channel which should not be watched without the permission of the programme provider.

Filmnet is uplinked from Belgium mainly in English with Dutch subtitles and is another film channel. The same channel is used by World Public News for its morning schedule dealing with current affairs in English and French. There is also a feed to Israel in English.

Olympus is a Pan-European tv station run by the European Broadcasting Union and contains material from its members. Materials is of a similar format to conventional tv with European news, current affairs, travel, music, films, etc. It is hoped that material broadcast in the language of the providing country will be available in teletext subtitles to other language groups.

Worldnet is provided by the US Information Agency based on the previous night's US news boradcast, and intended for US embassies around Europe.

So far everything has been in PAL colour; now a couple of odd men out. TV5 in SECAM transmits the best of French-language tv from France, Belgium and Switzerland, with about four hours of programmes per night of a general mix.

The New World Channel (EBNET) is uplinked from Norway and is a multi-lingual religious transmission now in PAL.

Sat 1 is a German channel which although PAL has sound-in-sync and the short sync pulse distorts the picture. Without the correct decoder no sound is possible, however on this and other sound-in-sync channels an audio subcarrier has been found at around 3.5MHz but very distorted. This may be an analogue component of the digital waveform and will require further investigation. Sat1 also carries a VOA pop music and news programme in English on an audio subcarrier.

Sky Channel, the first satellite tv operator that predates ECS1, was operational on the Orbital Test Satellite (OTS 2). The audio, which includes both mono and stereo subcarriers, is clear but the video is inverted.

Music Box is an 18 hour pop-video channel, available with both a mono and stereo subcarrier; the stereo is companded and requires expansion.

On the Eastern spot is Luxembourg in German and Sat 3 (sound-in-sync) but the signal is too weak from a 1.6m dish for reception in the UK and at least a 3m dish is needed.

The terms of the licence are that the material must be for ultimate public reception, and a considerable amount of material on **ECS 2** does not fall into this bracket. For example, feeds to the USA are run where conversations at set up time are transmitted when the viewer would be watching a 'commercial' and language can be Anglo-Saxon in the extreme! The Eurovision song contest goes through this satellite, as do many of the sports exchanges. Material is mostly sound-in-sync. Sweden has two transponders operational but with a non-public reception system. Norway has a C-MAC transponder, which requires a special decoder.

Test transmissions from the Soviet Union have recently been received from the 14°W **Gorizont** on 11.640GHz. The transmission is by circular polarization which requires a simple and cheap modification to the feed horn if a 3dB loss is not to be incurred.

Had **ECS 3** not had to be destroyed there would have been another 12 transponders available very shortly, but now we will have to wait till the ground spare can be fitted into the launch schedule*.

Other 11GHz satellites carry the point-to-point telephone network between the UK and USA and it is an offence to attempt to receive these transmissions. A news feed from the BBC has recently been seen on the 18°W Intelsat.

For those with teletext receivers, many of the transponders carry a text service which gives details of future programme material, as well as other interesting data.

System costs

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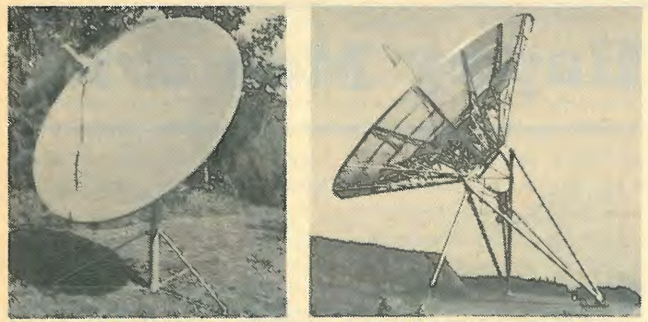

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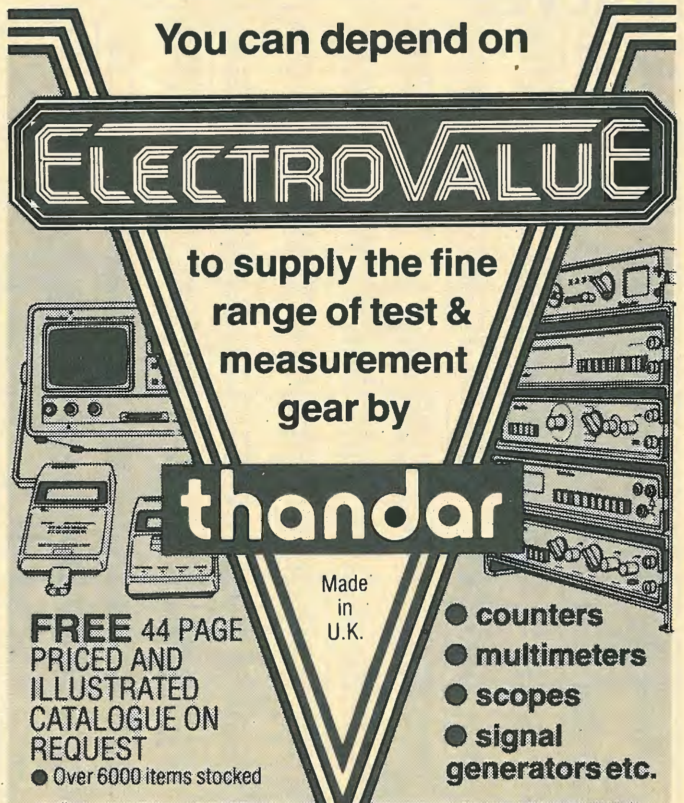

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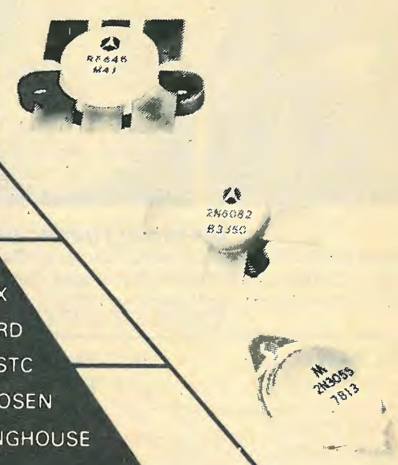

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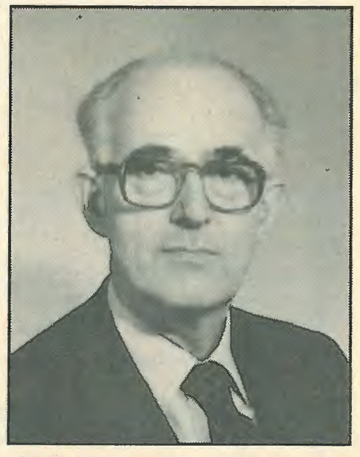


David Withers, who retired as chief engineer of BT International in 1985, is a consultant in satellite communication. For the last ten years he has chaired a CCIR working party studying ways of achieving efficient use of the g.s.o. by the fixed-satellite service.

A conference of the ITU has decided to change the basis of regulating the use of the radio spectrum for satellite communication so that every country will have a guaranteed option of setting up a national system.

Developing countries complain that the developed countries are seizing most of the available positions in the geostationary satellite orbit for their own satellites. Countries that may want to set up their first national satellite system in 10 or 20 years' time fear that there will be no room left for them. Changes are being demanded in the international regulation of the use of the orbit and the radio spectrum, in particular for satellites that interconnect fixed earth stations (the fixed-satellite service or FSS), to guarantee access for all countries, no matter how late they start.

A guarantee of equitable access to orbit and spectrum for the FSS presents real problems. The ITU is an international body, not a supranational one, and the policies which could be followed to achieve equitable use of the g.s.o. for the FSS are only those which all member governments can agree to implement. All countries support justice in principle, but there will also be insistence on protection of existing systems and current growth and a limit on the near-term economic impact of changes designed to provide for uncertain needs in the distant future.

Every national government reserves to itself the right to assign frequencies to radio stations within its jurisdiction. The basic method that is used to keep order in the radio spectrum involves international registration through the ITU of national frequency assignments that have been shown not to cause unacceptable interference to one another; a new assignment is added to the register if it raises no interference problems with assignments which are already registered. Governments undertake not to allow their radio stations to interfere with stations using internationally registered assignments. This principle has been elaborated into a frequency coordination procedure for space radio services. It has been called "first come, first served" by its critics, with truth. It works fairly well but it is not equitable.

The only other method that has been found to work, and which is used for some services and in some frequency bands, is radically different. This consists of drawing up a plan for the use of the band, based not on present or planned use but on the stated national requirements. So-called *a-priori* frequency assignment plans have been used, for example, for some terrestrial services and for satellite broadcasting in the 12GHz band. This method provides guaranteed access to a late-comer country. It also provides stability of frequency usage and this is of great value for some radio services and especially for broadcasting. The much greater versatility and changeability of the FSS makes the *a-priori* method particularly unsuitable for that service.

The most serious drawback of *a-priori* planning, however, is that the ITU has never found a way of sharing the medium between countries in proportion to their actual needs; it has only been able to share it in accordance with the stated requirements of each country, and in practice this has usually involved assigning equal shares to all countries, large and small. It is like sharing a cake. Sharing a cake between about 160 claimants can lead to small portions. It is possible to make the cake bigger by requiring all systems to meet high technical standards, but at a price. If the portions are to be big enough for the bigger users, the price is likely to be very high, and it is money wasted if many assignments are not used, as is likely with *a-priori* plan.

Coordination is clearly more effective and economic for the FSS than *a-priori* planning, but can it meet the needs of late-comer countries? Growth in the FSS is buoyant. Indeed there is little doubt that the rate of growth of national satellite networks for developing countries would be determined mainly by the availability of capital to finance them, given that orbital slots could be found for all the new satellites. The demand might eventually top-out as the scale of traffic on major domestic telephone routes rises to the point where terrestrial transmission media such as radio relay and optical fibre cables compete economically with satellite networks but this will take a long time. Thus, much depends on the feasibility of finding enough orbital slots to meet the demand.

So far it has always been possible to find a slot for a satellite by using the coordination procedure, although it is getting difficult in the more crowded arcs. Finding enough room for future growth is primarily a technical matter. A great deal has already been done, mainly through the ITU, to reduce the minimum acceptable separation between satellites and so to increase the number of slots. By 1987 all newly launched geostationary satellites will have to be maintained very precisely on station. The level of inter-network interference which all networks are recommended to accept has been increased by stages over the years and further increases are impending. Considerable progress has been made in reducing the gain of earth station antennas in the direction, not of their own satellite but toward other satellites nearby in orbit. There is much more that could be done. In particular:

- The geographical area covered by satellite antenna beams could be tailored much more closely to the required service area, with a

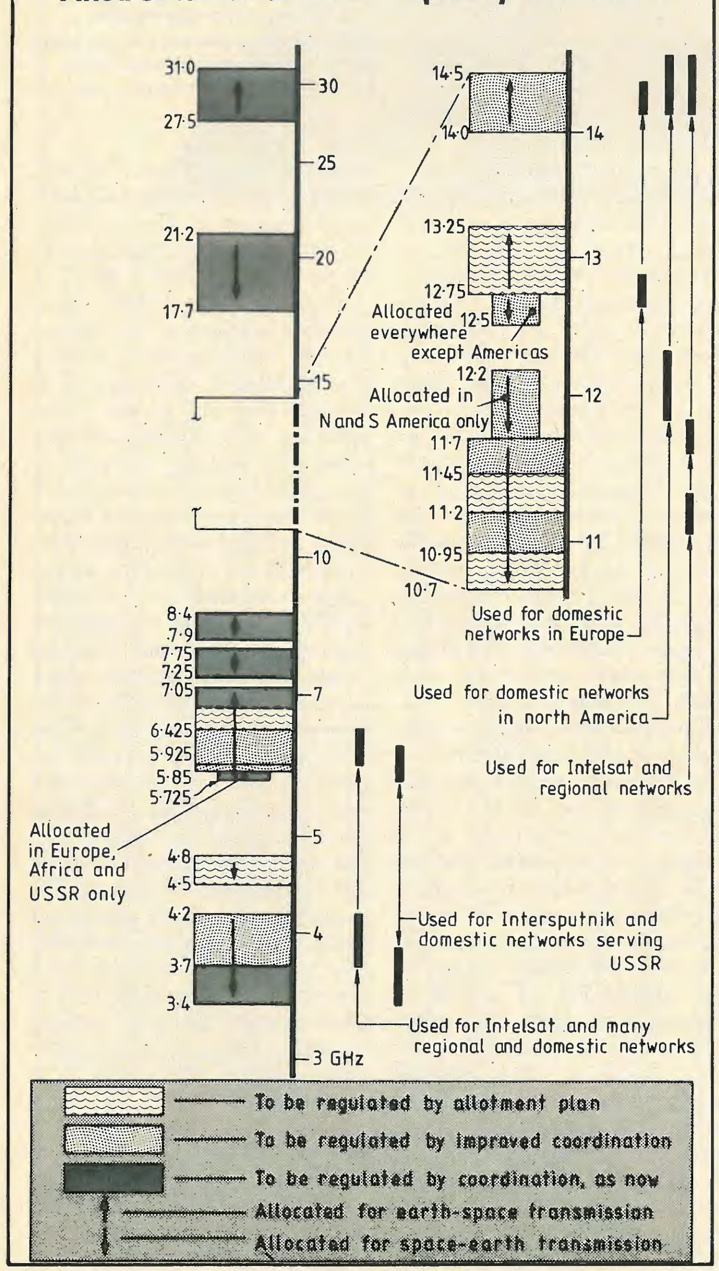
Delegates of over a hundred countries attended a conference in Geneva, 8 August to 15 September 1985 under the aegis of the International Telecommunication Union (ITU) with the chief item of finding ways of guaranteeing equitable access to the Clarke Orbit. There is to be a second session of the conference in 1988, whose full title is "the World Administrative Radio Conference on the use of the geostationary satellite orbit and the planning of space services utilizing it" or WARC-85 for short.

- The process of coordinating satellites which are neighbours in orbit should be much more effective and could benefit from more cooperative attitudes on the part of negotiators.
- Some specific types of radio signal are particularly susceptible to interference from other specific types of signal. Segmentation of the spectrum to ensure that these signal types are not assigned the same frequency channel in different satellites could yield considerable benefits.

Given all of these further improvements, the number of satellites that could operate in the FSS would be very great. The number will grow from decade to decade as better hardware becomes available at affordable prices. For example, much depends on the smallness of satellite antenna beams and therefore on the largeness of the antenna reflectors that can be launched as a piece or unfurled or erected in space. However studies made in CCIR, assuming the use of only those frequency bands which are already in general application and no new launcher facilities, have come up with an estimate of 1000 satellites.

Progress is being made in all of these areas in the ITU and in particular in the CCIR. Agreement comes only slowly because these changes of technology and practice tend to be more costly than he changes that have already been adopted. The price presents itself in a variety of ways; in the capital cost of satellites, in lost business opportunities, in operational difficulties in working networks and in increased planning costs. Ways will be found for reducing these costs and finding the best combination of measures, from decade to decade, that will provide for the growth in global capacity that is required by growing demands at a cost that can be borne. Despite this prospect of improvement, it cannot be said that coordination offers a bankable guarantee of equitable access.

Fixed-satellite service frequency allocations



The agreement at WARC-85

After prolonged discussions WARC-85 agreed to a compromise between efficiency and reassurance in the form of a package of proposals for the FSS. In future, three regulatory methods will be applied to the FSS in its various frequency bands.

One group of frequency bands will be regulated by *a-priori* planning. This will not be the very rigid form of frequency assignment planning used, for example, for satellite broadcasting. A new and more flexible process called frequency allotment planning, much better suited to the multifarious and changeable FSS, is to be developed. These plans will provide a guaranteed allotment for every country, available for use whenever the need arises.

A second group of frequency bands will continue to be regulated by coordination methods, but these methods will be improved in order that these bands might better carry the heavy traffic load that will develop in the future. No doubt international systems like Intelsat will be substantial users of these bands in the future, but there will be no bar to their use for national systems, and they will undoubtedly be so used, for example when the capacity provided by the allotment plan is insufficient to meet national needs.

The remaining frequency bands allocated to the FSS would be regulated basically as now, but the procedures are to be reviewed and amended if ways can be found to facilitate their application.

The *a-priori* frequency allotment plans are to be drawn up for two sets of frequency bands,

- one, with a transmission bandwidth of 300MHz, with earth to space links around 6.7GHz and space to earth links around 4.6GHz
- and the other with a transmission bandwidth of 500MHz, with earth to space links around 10.8 and 11.4GHz and space to earth links around 13GHz.

These bands were first allocated to the FSS in 1979 and have not been taken into use yet to any considerable extent.

The form which the allotment plan would take has not been worked out in detail yet, but it is likely to be broadly as follows.

- The g.s.o. would be divided into short orbital arcs, each allotted for the satellites of a short list of countries.
- Some of the basic technical parameters would be defined within which all networks must operate, such as satellite antenna and earth station antenna out-of-beam gain, spectral power radiation density and interference sensitivity.
- A bandwidth would be allotted to each country within the agreed frequency bands and the permitted service area would be defined. The whole bandwidth available in both sets of bands, namely 800MHz, will probably be allotted for the use of each country, unless this would demand unacceptably stringent technical parameters.

Each country's guarantee of access arises from its inclusion in the allotment plan. The plan would be flexible, within limits, aloowing a range of network parameters to be used and leving some latitude for countries to group together, if they wish, to set up a satellite jointly. When a country or a group of coutnries is ready to take up an allotment and launch a satellite, it would discuss its proposals with other countries with working satellites or allotments nearby in the geostationary orbit register the assignemtns after successful coordination.

Improved procedures based on the present coordination pro-

continued on page 75

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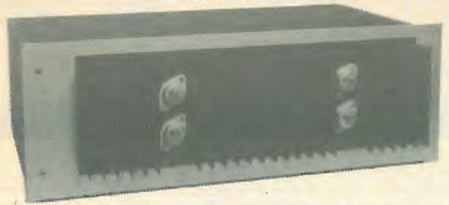

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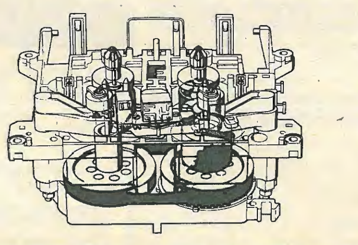

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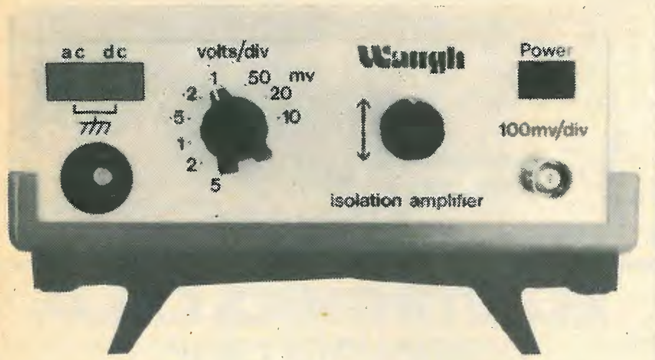

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CIRCLE 72 FOR FURTHER DETAILS.

Polyphonic keyboard — 4

by D. J. Greaves B.A.

Audio and interface circuits of David Greaves' digital musical instrument

Push-to-make switches are used on the front panel. These are wired in a rectangular array of three rows by right columns. Since no two buttons in the same row need be pressed at once, multiplexing diodes are not necessary.

The columns connect directly to the Q-bus. This bus is terminated with 2.2kΩ pull-up resistors which reduce line ringing and provide a logical one if a switch is not pressed. The rows are fed from open collector buffers which pull the row line low when the 8088 wants to read the switches. If a switch is pressed, a line in the Q-bus will be pulled low when the row line is pulled low. Debouncing of the switches is performed in software.

The front panel leds are controlled by writing to a single eight-bit latch consisting of $IC_{48,49}$. For economy, a single 74LS374 could be substituted for these two integrated circuits. Ten sets of single leds or pairs of leds need to be addressed so decoder IC_{63} is used to extend the eight available bits.

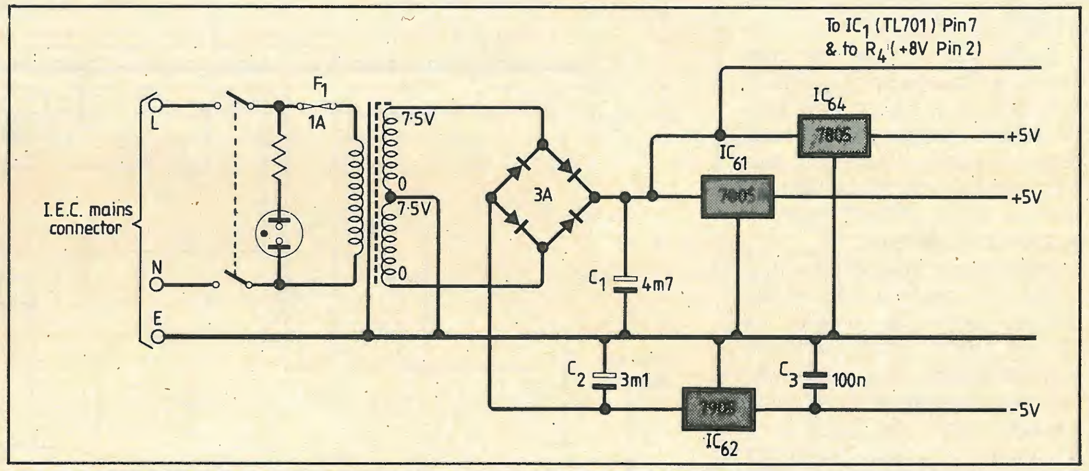
Analogue electronics

Component IC_{32} is the control digital-to-analogue converter. It is an eight bit device and produces a voltage on pin two proportional to the number that the 8088 has put into IC_{31}.

Control-converter voltage is fed to the comparator, IC_1 where it is compared with the front panel knob voltage to give a single above/below bit. This bit is gated onto the Q-bus by IC_{23} when the 8088 reads the status port. The control convertor also feeds IC_{37}, a CD4051 eight way bilateral switch.

When the 8088 writes to its influence register, one of the switches in IC_{37} is enabled and this feeds the control voltage to one of five holding capacitors. These are the five sample-and-hold circuits described earlier.

Holding capacitor C_{15} is buffered by IC_{44}. This capacitor sets the tremolo and vibrato oscillator frequency. The oscillator is a standard phase-shift ring type based around half of IC_{46}. Its output feeds $IC_{40,\ 45}$, both CA3080 variable



Polyphonic keyboard i.c. list

1	TL701	KNOB comparator
2	74LS161	Microcode address upper 4 bits
3	6349-1	Microcode prom
4	74LS734	Current op-code reg.
5	74LS154	Op-code decoder
6	TMM2016P	2K × 8 100ns ram
7	74LS181	Lower four a.l.u. bits
8	74LS181	Upper four a.l.u. bits
9	74LS74	Host command 2-bit shift reg.
10	74LS161	Microcode address lower four bits
11	74LS126	Addressing mode steering
12	74LS157	Host-command address switch
13	74LS244	V-reg. buffer
14	74LS373	Host data reg.
15	74LS374	Audio d-to-a converter reg.
16	74LS245	A-bus to D-bus buffer
17	74LS374	Accumulator
18	74LS245	Indexed addressing buffer
19	74LS04	
20	74LSO2	
21	74LS08	
22	74LS161	V-reg.
23	74LS367	Status port buffers
24	74LS00	
25	74LS373	Data for host index reg.
26	74LS04	
27	DAC0801	Audio output converter
28	74LS373	Data destination reg. & Midi out
30	74LS154	Host reg. address decode
31	74LS373	Control converter reg. & key scan address
32	DAC0801	Control d-to-a converter
33	74LS00	Carry-bit logic
34	74LS74	Carry-bit reg.
35	74LS10	Converter address detector
36	74LS00	
37	CD4051	Converter influence reg.
38	741	Audio output filter
39	TL081	Fine pitch control
40	TL081	Vibrato depth control
41	74LS13	Master clock Schmitt trigger
42	CA3080	Tremolo depth amplifier
43	TL062	Tremolo-depth/timebase-speed buffer
44	TL081	Tremolo and vibrato-speed buffer
45	CA3080	Vibrato depth amplifier
46	SFC2458	Tremolo and vibrato osc.
47	7407	Front panel o.c. buffer
48	74LS161	Upper led latch
49	74LS161	Lower led latch
50	8284	8088 clock generator
51	8088	processor
52	HMM6116LP-3	2K × 8 c-mos memory
53	2764	8K × 8 n-mos eprom
54	74LS10	8088 address decoding
55	74LS373	8088 lower address bus latch
56	74LS245	8088 i/o transceiver
57	7805	8088 5V regulator
58	74LS04	8088 logic
59	74LS00	8088 logic
60	74LS10	8088 i/o decoder
61	7805	5V regulator
62	7905	– 5V regulator
63	74LS138	Front-panel led controller
64	7805	Microcode logic regulator
65	74LS04	Midi data buffer

transconductance amplifiers. Their transconductance is set by a current into pin five.

Similar circuits are used for both 3080 devices consisting of transistor constant-current generators whose current is set by one of the influence register sample and hold circuits.

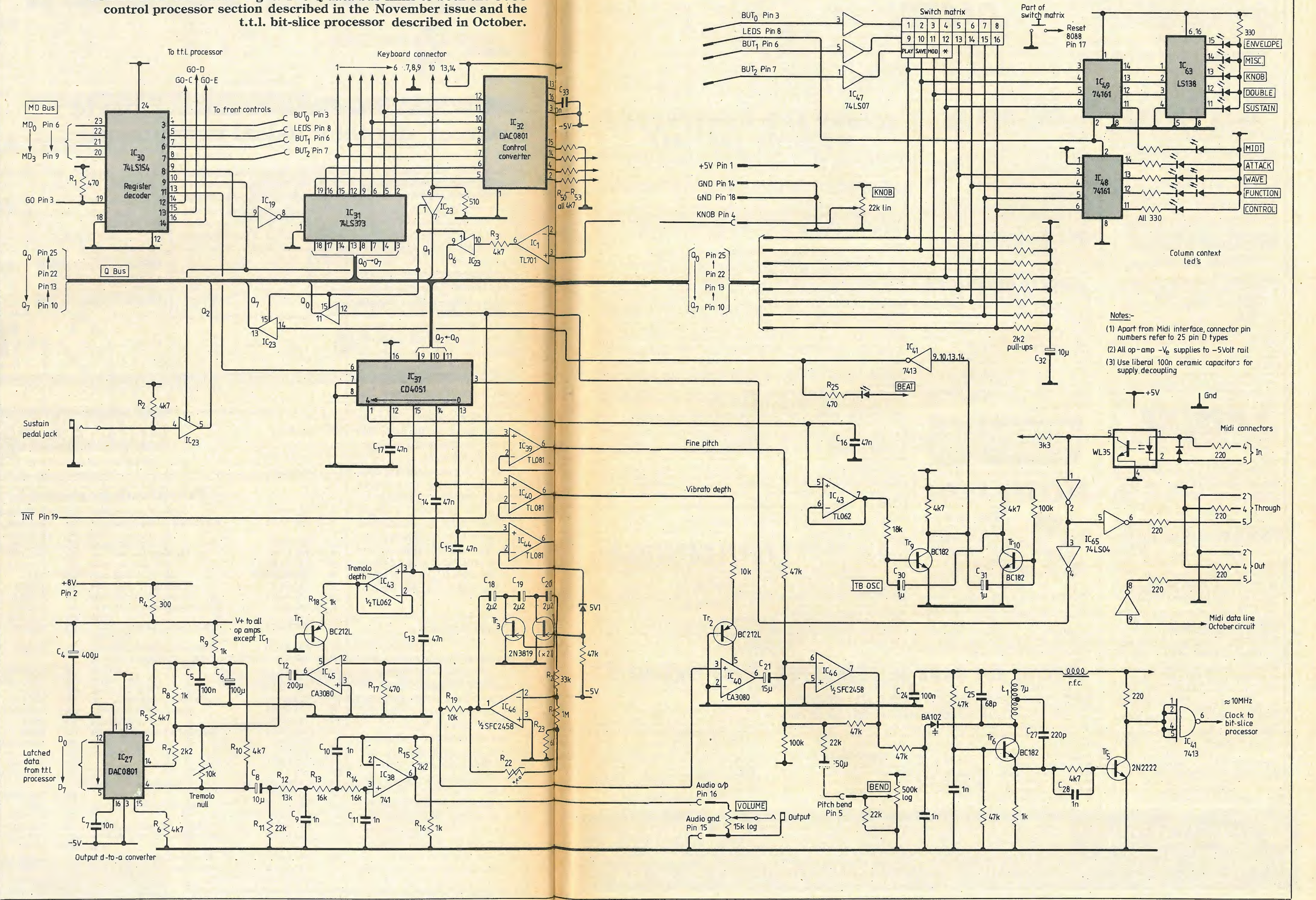
Amplifier IC_{45} modulates reference current in the audio-output converter IC_{27} to provide a tremolo effect. Because the converter zero output is actually half way through its range, the tremolo modulates the d.c. level of the output. This effect can be nulled by adjusting the tremolo null potentiometer to add an opposite d.c. modulation directly to the output. The potentiometer is the only preset requirement in the whole instrument.

Audio output from the converter is filtered by IC_{38} which is wired as a Sallen and Key three-pole low-pass filter with pass-band gain of three and cut-off frequency of 5kHz. Output level is about 200mV when a single key is pressed.

Component IC_{40} feeds IC_{46} which controls frequency of the master clock to provide a vibrato effect. Along with the vibrato signal, IC_{46} sums the fine pitch setting from IC_{39} and voltage from the pitch-bend front-panel control. Output of IC_{46} biases a voltage-controlled capacitor in the tank circuit of the clock. For a swing from +5 to −10V in bias, clock frequency varies by about 1.5MHz in 10MHz. However this range is not all needed and only a positive and negative swing of about 2V is produced by IC_{46}. A swing of 600kHz in the master clock changes the instrument pitch by one semitone.

Control-converter register IC_{31} is also used to read the keyboard. The prototype keyboard has a built-in digital encoder provided with a 14-pin dil header connector. A five octave C-to-C keyboard has 61 notes which therefore need a six bit address.

The six least-significant bits of IC_{31} are fed to the keyboard and a single bit is returned. Numbering the lowest C as zero, if the key addressed by the six-bit number is pressed, then a logical one is returned, otherwise a zero. The bit is buffered by IC_{23} onto the Q-bus so that it appears as bit one in the 8088 status port.



Digital-to-analogue conversion, interfacing and audio processing are main functions of this final section of the digital polyphonic keyboard. Midi i/o is on the middle right. The Q data bus links to both the 8088 control processor section described in the November issue and the t.t.l. bit-slice processor described in October.

Notes:-

(1) Apart from Midi interface, connector pin numbers refer to 25 pin D types

(2) All op-amp $-V_e$ supplies to −5Volt rail

(3) Use liberal 100n ceramic capacitors for supply decoupling

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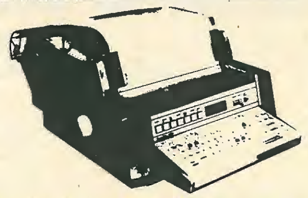

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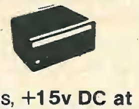

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Gisle K. Dyvik

Fast Fourier transform

September's program, by Dyvik and Larsen, needs a correctly-formatted random access data file to work on

Some readers have vainly tried to run the program listed in September's issue*, according to one 'even shifting the program down to &E00'. I must admit that this thought never struck me in writing the text, or else I should have explicitly warned against the waste of effort! True, the program appears deceptively short, being some 3563 bytes long in published form. However, it is extremely greedy on memory for its syndamic variables, due to all the arrays involved. After compacting, it occupies some 2030 bytes and even so the PAGE must be lowered to &1300, which is as low as it can be set catering for the necessary random access files to be used.

The compacted version of the program represents a nearly illegible piece of listing, which is why we didn't use it instead of the full-blown listing in the first place. In contrast to some other methods of compacting — which translate Basic keywords into their internal equivalents — the present compacted version is still completely Basic-compatible on the highest level: the compacting has been effected only by removing unnecessary spaces, REMs, line numbers, using shorter names for variables, functions and procedures (implying that the version will tolerate a certain amount of tampering even after compacting. But please note that the few open spaces left in the program lines proper are crucial).

The FFT listing needs a correctly formatted random access data file to work on, containing successively the number of samples to be treated (256), and the actual numbers representing the (256) data to be input. We assumed that such a file could be generated by most readers with a little knowledge of random access files, but in case of difficulty I have prepared a tiny data-generating Basic-program for this purpose, see FUNCTN listing.

A disc containing the compacted version is available*. In addition to FFTCOMP, it contains the data files referred to in the article (five files: F. EXAMPLE, and F. EX1DATA to F.EX5DATA) and also a screen dump routine (PRINTER) for Epson MX80/FX80 and compatible printers. To provide enough memory for running the program, PAGE should be lowered to &1300 before loading or chaining FFTCOMP (the penalty for which is that the program becomes corrupted during the execution, and must be reloaded afresh from disc for a new run).

As mentioned in the article, only slight modifications are needed in the program to demonstrate a digital filtering effect as well. I have included a version on the disc that will do this (FFTFILT). Once more, the "PAGE=&1300" bit is necessary before running the program. As memory really is at a premium, this program is very skimpy on the text side, but it should be fairly self-explanatory.

While I have been exclusively working with Basic 2 for a long time, it struck me that some readers might still have Basic1 in their machines. I have therefore carried out tests to check the compatability of the program with Basic1, and it turns out that it needs to have the word OPENIN inserted near the start of line 810. After that, it will run on both Basic versions. (The disc programs would also need the addition of the word OPENIN in line 810 to work with Basic1, of course.)

LISTING OF "FFTCOMP"

```
   10DIMAA 20:PROCAA:MODE0:PROCBA:TIME=0:PROCCA:PROCDA:FORI%=1TOL%:Q%=0:R%=J%:FO
RK%=1TOP%:X%=Q%/J%:S%=USR(AA) DIV&FFFF AND&FF:Z1=R(S%):Z2=S(S%):FORM%=Q%TOR%-1:A
1=D(M%):A2=E(M%):U%=M%+J%:B1=Z1*D(U%)-Z2*E(U%):B2=Z2*D(U%)+Z1*E(U%)
  240D(M%)=A1+B1:E(M%)=A2+B2:D(U%)=A1-B1:E(U%)=A2-B2:NEXT:Q%=Q%+2*J%:R%=R%+2*J%:
NEXT:PRINTTAB(42+I%,18)"-":J%=J%DIV2:P%=2*P%:NEXT:B%=0:FORX%=0TON%DIV2:Y%=USR(AA
)DIV&FFFFAND&FF:Q(X%)=SQR(D(Y%)*D(Y%)+E(Y%)*E(Y%)):IFQ(X%)>B%THENB%=Q(X%)
  350NEXT:PRINTTAB(15,18)STRING$(40," "):T%=60:VDU5:O%=2^(11-L%):K=100/B%:FORZ%=
0TON%DIV2:H%=INT(Q(Z%)*K+.5):MOVET%,160:PLOT1,0,4.2*H%:IFH%>EATHENPLOT0,-20,40:P
RINTH%
  420T%=T%+O%:NEXT:PROCEA:END
  480DEFPROCBA:L%=8:N%=256:P%=1:J%=N%/2:F%=N%-1:H%=F%DIV2:G%=H%DIV2+1:DIMD(F%),E
(F%),Q(J%),R(H%),S(H%):VDU23,248,24,24,24,24,24,126,60,24
  500INPUTTAB(10,10)" Which data file to be used? (<RTN> gives F.EXAMPLE)  "N$:C
LS:IFN$=""THENN$="F.EXAMPLE"
  550INPUTTAB(10,10)" Lower limit for per centage ?  (<RTN> gives 10)  "EA:CLS:I
FEA=0THENEA=9
  570VDU23;8202;0;0;0;:ENDPROC
  600DEFPROCAA:P%=AA:[OPT2:CLC:TXA:STA&70:LDX#8:.FA:LDA&70:ROLA:STA&70:TYA:RORA:
TAY:DEX:BNEFA:RTS:]:ENDPROC
  810DEFPROCCA:A=OPENINN$:INPUT#A,f:M=0:FORZ%=0TOF%:INPUT#A,D(Z%):M=M+D(Z%):NEXT
:CLOSE#A:GA=M/N%:FORZ%=0TOF%:D(Z%)=D(Z%)-GA:NEXT:FORI%=0TOG%:R(I%)=COS(I%*PI/128
):NEXT
  850FORI%=0TOG%:S(I%)=R(G%-I%):NEXT:FORI%=G%TOH%:R(I%)=-S(I%-G%):S(I%)=R(I%-G%)
:NEXT:ENDPROC
  930DEFPROCDA:@%=&020207:F=f/N%:PRINTTAB(21,2)"***  FAST FOURIER TRANSFORM  ***
":PRINTTAB(21,3)"   (BBC BASIC/HYBRID VERSION)":MOVE50,150:DRAW1100,150
  980MOVE50,150:DRAW50,650:PROCFA(0,0,1279,1023):PROCFA(255,703,1024,831):PRINTT
AB(69,27)"FREQ."
 1020PRINTTAB(1,11)"AMPL.          Freq.  at  "CHR$(248)" :":PRINTTAB(17,18)"COM
PUTATIONS IN PROGRESS:":PRINTTAB(43,18)STRING$(L%+1,"*")
 1050VDU5:MOVE50,142:PRINT"FREQUENCY INTERVAL: ";F;"Hz":VDU4:MOVE256,768:FORX%=0
TOF%:DRAWX%*3+255,768+D(X%):NEXT:@%=&0302:ENDPROC
 1130DEFPROCFA(r%,s%,t%,u%):MOVEr%,s%:DRAWr%,u%:DRAWt%,u%:DRAWt%,s%:DRAWr%,s%:EN
DPROC
 1190DEFPROCEA:VDU4:PRINTTAB(25,30)"PUSH <ESC> FOR PRINTER COPY!",TAB(53,11)"Tim
e: ";TIME/100"s":VDU5:X%=200:Y%=200:*FX4,1
 1230*FX11,5
 1240*FX 12,1
 1250*FX229,1
 1260MOVEX%,Y%:GCOL3,7:VDU248:REPEAT:K%=GET:VDU8:VDU248:IFK%=27THENGCOL0,1:VDU8:
VDU248:PROCGA:ENDPROC
 1290IFK%=136THENX%=X%-2ELSEIFK%=137THENX%=X%+2
 1300IFK%=138THENY%=Y%-2ELSEIFK%=139THENY%=Y%+2
 1310IFX%<54THENX%=54ELSEIFX%>1078THENX%=1078
 1320IFY%<200THENY%=200ELSEIFY%>630THENY%=630
 1330MOVEX%,Y%:VDU248:VDU4:PRINTTAB(30,11)INT((X%-54)/8*F+.5)" Hz":VDU5:UNTILFAL
SE:ENDPROC
 1380DEFPROCGA:VDU2
 1410*PRINTER
 1420VDU3:ENDPROC
```

LISTING OF "FUNCTN"

```
 10 REM: THIS PROGRAM DEMONSTRATES HOW DATA FOR TESTING THE
 20 REM: "FFTCOMP" PROGRAM CAN BE GENERATED. ANY CONVENIENI
 30 REM: MATHEMATICAL EXPRESSION FOR A PERIODIC FUNCTION COULD
 31 REM: BE USED, PREFERABLY WITH AN INTEGER NUMBER OF PERIODS
 32 REM: FOR THE SAMPLING INTERVAL (TO AVOID "WINDOW" EFFECTS!)
 33 REM: THE EXAMPLE SUGGESTED WILL GIVE 5 PERIODS OF A 5 Hz
 40 REM: SINE-WAVE WITH SUITABLE AMPLITUDE, ASSUMING THAT THE
 41 REM: TOTAL SAMPLING TIME REPRESENTS 1 SECOND.
 50
 60 REM: ANSWERING "45*SIN(5*X)+15*SIN(15*X)+9*SIN(25*X)" IN STEAD,
 70 REM: WHEN ASKED FOR A FUNCTION, WOULD GIVE A COMPOSITE WAVE
 80 REM: TRAIN, RESULTING IN FREQUENCY LINES AT 5Hz, 15Hz, 25Hz
 90 REM: WITH AMPLITUDES IN THE RATIOS CORRESPONDING TO THE THREE
 91 REM: FIRST FOURIER TERMS OF A 5 Hz SQUARE WAVE. ETC,ETC.
100
110 REM: EXAMPLES OF SUITABLE, PIECE-WISE CONTINUOUS FUNCTIONS
120 REM: (LIKE PERFECT SQUARE WAVE, SAW-TOOTH, ETC.) CAN BE
130 REM: GENERATED FROM SMALL BASIC PROGRAMS, TAILORED FOR THE
140 REM: PURPOSE: BY SUBDIVIDING THE ABSCISSA VALUES INTO GROUPS
150 REM: THAT CORRESPOND TO THE CONTINUOUS PORTIONS - WHERE THE
160 REM: VALUES OF THE FUNCTION CAN BE COMPUTED BY SIMPLE MATHE-
170 REM: MATICAL EXPRESSIONS ---- .
180
190 MODE 0
200 INPUTTAB(10,10)"GIVE YOUR FILE A NAME,PLEASE!      "B$
210 X=0
220 DIM Y(255)
230 PRINT:PRINT
240 INPUTTAB(0,10)"WRITE THE FUNCTION HERE (example: ""50*SIN(5*X)"") "A$
250 MOVE 0,400
260 FOR I= 0 TO 255
270 Y(I)=EVAL(A$)
280 DRAW X*200 ,Y(I)+400
290 X=X+PI/128
300 NEXT
310 R=OPENOUT B$
320 PRINT #R, 256
330 FOR I=0 TO 255
340 PRINT #R, Y(I)
350 NEXT
360 CLOSE #R
```

---

*Fast Fourier transforms using a microcomputer, by G.K. Dyvik & T. Larsen, pages 80-2.

*Please send a formatted disc together with stamped and addressed envelope to the editorial office, envelope marked FFT.

The deeper hidden message

from page 34

which leads to the disintegration of competence among the knowledge professionals as well as the prevention of the ingress of new knowledge. Something like this syndrome is needed to explain the survival of Maxwell's Equations for so long.

Moving graphics help to illustrate the subtleties of electromagnetic theory. For information on the availability of videotapes, please write to Ivor Catt, 15 King Harry Lane, St Albans AL3 4AS.

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Equitable access to satellite communications

continued from page 66

cedures would be applied in the frequency bands where most FSS networks operate now, namely a bandwidth of 500MHz at 6 and 4GHz and another 500MHz bandwidth at 14 and 11GHz. There was discussion at WARC-ORB as to what changes should be made to the methods used in these bands. No decisions were taken, but the improvements are likely to be selected from among the following:

(a) The present procedure, based on advance publication of an outline of the technical details of a planned system, followed by multiple bilateral coordination negotiations, is becoming cumbersome to operate. It may be replaced by multi-lateral negotiations which could take the form of a conference every couple of years attended by representatives of every country with an FSS satellite in orbit or with plans for launching within say five years.
(b) The concept of spectrum segmentation may be developed for reducing the incompatibilities between different networks having satellites which are neighbours in orbit.
(c) The technical principles of coordination may be simplified in order to make the process of harmonization more amenable to computation in a multi-lateral environment.
(d) A stimulus might be given to cooperation between countries sharing an arc by the formulation of principles of burden-sharing.
(e) A more systematic approach may be made to the periodical up-grading of technical standards.

The allotment plan is to be prepared and the new coordination procedures are to be agreed at the second session of the conference, in 1988. Extensive preparatory work will be necessary meanwhile.

Broadcasting

While guaranteeing equitable access to the g.s.o. for all countries was the chief task of this Conference, its other activities, all related to satellite broadcasting, are also interesting. The frequency assignment plan for satellite broadcasting at 12GHz in North and South America was given formal approval. parameters for the links which will be used to feed programme material to satellites broadcasting in other partsof the world were discussed and agreed; a plan for these feeder links is to be drawn up at the 1988 conference. Proposals for sound broadcasting by satellite, suitable for reception on portable or car receivers, were considered; there is a major problem here in that it has not been possible yet to find a suitable frequency band that could be allocated for this purpose but the search continues and the 1988 conference will return to the matter.

Finally, WARC-85 discussed ways of providing for high definition television broadcasting by satellite. In two of the three Regions into which the ITU divides the world there is a frequency band for satellite broadcasting at 22GHz, but this does not include Eurpe. Now that the 12GHz direct broadcast band is planned world-wide for 625 and 525-line tv, there is a lot of interest, particularly in Japan and USA, in using the 22GHz band for high definition systems needing much more channel bandwidth. This enthusiasm is spreading to Europe and the feasibility of allocating a band at 22GHz world-wide will be discussed again in 1988 after further study of the problems posed by existing services already operating in the band.

David Withers is reporting WARC-85 in greater detail at OnLine's Satellite Communication 85 Conference, at the Tara Hotel, London, Dec 3/4. Proceedings are available from OnLine at 01-868 4466.

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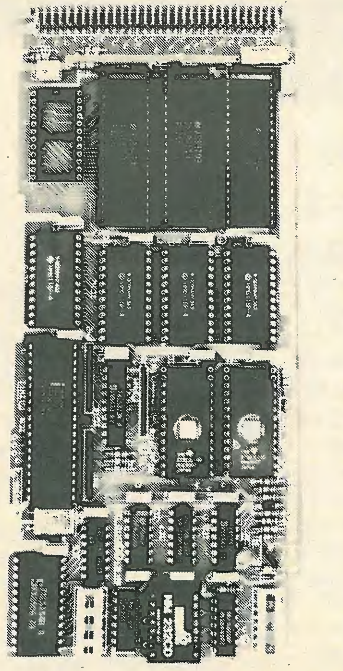

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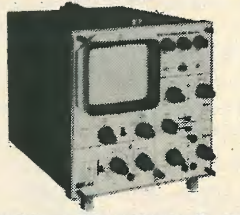

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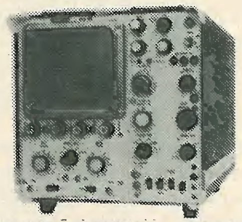

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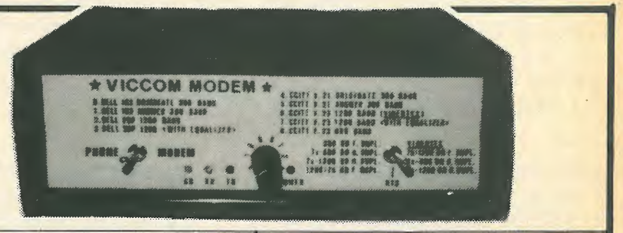

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Modems

To supplement last month's article, a survey of two-wire and four-wire modems for dial-up or leased lines

Tandata's new Tm602 modem combines V.21, V.22 and V.23 modes. It has a variety of advanced features such as auto-dial, auto-answer, data buffering and a self-test routine. Software control is by a command string which can include telephone number, data rate and passwords.

In this survey we have concentrated on general-purpose modems suitable for use with a wide range of computer systems. For individual computers there are in addition many special-purpose modems: plug-in cards for the IBM p.c. and its rivals, cartridges for the CBM64, firmware-controlled modems for the Sinclair QL, the Amstrad, the BBC Micro and so on.

The modems listed in the table are designed for use on leased lines or over the public telephone network.

Most models listed are CCITT-standard, mains-powered, table-top units for direct connection to the telephone line.

The table shows their basic specifications, though many of the more expensive modems have advanced features which cannot be described in detail here. A few of the commonest are the following:

- Bell modes, for communication with computer systems in the Americas
- Software control of modem configuration, test routines etc.
- Automatic dialling on the public telephone network (in leased-line modems, for back-up circuits)
- Automatic answering of calls
- Hayes protocol compatibility
- Error detection and correction to protect transmitted data
- Buffering of data to permit use with computers which cannot send and receive at different rates
- Data security: encryption of data in the transmission link
- Rack-mounting options for larger installations.

Another class of modem not included here is the short-haul modem or line-driver, which suits applications where the whole course of the line runs on private property. In such installations, the complexities of a BABT-specification modem are not needed and the traffic can be handled by a simpler and potentially cheaper device. Short-haul modems are obtainable for speeds of up to 9600 bit/s and more, and for distances up to a few tens of kilometres.

Addresses

Anglia Microwaves Ltd, Radford Business Centre, Radford Way, Billericay, Essex CM12 0BZ.
Answercall Ltd, Kangley Bridge Road, London SE26 5AH.
Black Box (Micom-Borer), PO Box 80, Reading, Berkshire RG2 0PS
British Telecom Business Systems (Merlin), Freepost, London SW1 8BR.
Computer and Systems Engineering p.l.c. (Case), P.O. Box 254, Caxton Way, Watford Business Park, Watford WD1 8XH
Computer Source (Viccom), Brahmslaan 129, 2625 BV Delft, The Netherlands.
DaCom Systems Ltd, Sunrise Parkway, Linford Wood, Milton Keynes MK14 6LU.
Datalines, 68 Alston Drive, Bradwell Abbey, Milton Keynes MK13 9HB.
DCE-Interlekt Ltd, 24 Portman Road, Reading RG3 1LU.
Epson (UK) Ltd, Dorland House, 388 High Road, Wembley, Middlesex HA9 6UH.
Ferranti Computer Systems Ltd, Simonsway, Wythenshawe, Manchester M22 5LA.
Gandalf Digital Communications Ltd, 19 Kingsland Grange, Wolston, Warrington WA1 4RW.
GEC Telecommunications Ltd, P.O Box 53, Coventry CV3 1HJ.
IAL Data Communications, Jays Close, Viables, Basingstoke, Hampshire RG22 4BY.
IBM United Kingdom Ltd, 389 Chiswick High Road, London W4 4AL.
Jaguar Communications Ltd, 32-34 Upper Marlborough Road, St Albans AL1 3UU.
Kirk Automation, Bridge Works, St White's Road, Cinderford, Gloucestershire GL1 4HV.
Master Systems (Data Products) Ltd, Network House, Stanhope Road, Camberley, Surrey GU15 3BW.
Micom-Borer Ltd, 15 Cradock Road, Reading RG2 0JT.
Micro Scope Videotex Systems, Mill Lane, Taplow, Maidenhead, Berkshire SL6 0AA.
Miracle Technology (UK) Ltd, St Peter's Street, Ipswich IP1 1XB.
Modem House (D.T.M.C. Ltd), 70 Longbrook Street, Exeter EX4 6AP.
Modular Technology Ltd, Zygal House, Telford Road, Bicester, Oxfordshire OX6 0XB.
Pace Micro Technology, 92 New Cross Street, Bradford BD5 8BS.
Racal-Milgo Ltd, Landata House, Station Road, Hook, Basingstoke, Hampshire RG27 9PE.
RS Components Ltd, PO Box 99, Corby, Northamptonshire NN17 9RS
Steebek Systems, 3 The Paddock, Hambridge Road, Newbury, Berkshire RG14 5TQ.
Tandata Marketing Ltd, Albert Road North, Malvern, Worcestershire WR14 2TL.
Telindus Ltd, 2-4 Oxford Road, Newbury, Berkshire RG13 1PA.
Trend Datalink Ltd, Knaves Beech Estate, Loudwater, High Wycombe, Buckinghamshire HP10 9QX.
Transam Microsystems Ltd, 59-61 Theobald's Road, London WC1X 8SF.

British Standards

Below is listed a selection of British Standard specifications dealing with data communications. Copies of these publications can be bought by post from the Sales Department, BSI, Linford Wood, Milton Keynes MK14 6LE.

BS 5397. High level data link control procedures.

BS6301: 1982. Specification for safety requirements for apparatus for connection to British Telecommunications networks.

BS 6305. Specification for general requirements for apparatus for connection to BT networks.

BS6320: 1982. Specification for modems for connection to the BT public switched telephone network.

BS 6328. Apparatus for connection to BT private circuits.

This low-cost viewdata modem from GEC is powered by the telephone line and requires no mains supply. For interfacing it to the BBC Micro, GEC are offering their own software package on rom or disc: as an extra feature, this allows chat and error-corrected file transfer at 1200 bit/s.

Further reading

Latest modem standards and details of all types of modems from 300 to 9600 bit/s are covered in a practical manner in the recently revised edition of The V Series Report: Standards for Data Transmission by Telephone. Details of this 60-page paperback book can be obtained from the publishers, Bootstrap Ltd, at Unit 1F, Sandyford Industrial Estate, Foxrock, Dublin. Its price is £10 sterling.

A useful primer describing the subject from the user's point of view is the CASE Pocket Book of Computer Communications. Its 84 pages, which selflessly omit to mention any of the company's products, explain serial transmission of data, communications lines and services, multiplexing, packet-switching techniques and complex protocols such as the ISO open systems interconnection model. There is also a useful glossary. The booklet is distributed by Computer and Systems Engineering plc, PO Box 254, Caxton Way, Watford Business Park, Watford WD1 8XH.

'Talking to the World' is the title of a 112-page paperback by John Newgas, who runs Britain's largest computer bulletin-board. It covers all aspects of low-speed data communications and provides a great deal of practical advice. The book is published by Century Communications at £5.95.

An informative guide to data communications from the poacher's standpoint is The Hacker's Handbook by Hugo Cornwall, Century Communications, 149 pages, £4.95.

Maker, model	Price	2/4	View-	CCITT modes								Bell	Soft	Auto-		Hayes	Error	Buf-	Rack	Data	Comments
	£	wire	data	21	23	22	/b	26	27	29	32	modes	ctrl	dial	ans	cptbl	corr.	-fer	mtg	security	
Answercall MM100	86	2		■																	low-cost model
BT Merlin Datel 413X	225	2		■											■						
Datel 4123X	295	2/4		■	■								■	■	■			■	□		
Datel 4122X	500	2				■							■	■	■				□		also equalizer model
Datel 4124X	695	2		■		■							■	■	■				■		
Datel 4241X	495	2/4					■	■/bis					■	■	■				□	■	
Datel 4242X	895	2					■						■	■	■		■		□		
Datel 4480X	1295	4/2							■/bis/ter				■	□	□		■		□		multi-point etc.
Datel 4960X	1995	2/4							■	■			■	□	□		■		□		
Datel 4961X	1695	4/2								■			■	□	□		■		□		
Datel 4962X	2800	2									■		■	■	■				□		four-port
Case 440/12		2	■	■	■								■	■	■		■			■	"hacker-proof"
460/22		2				■								□	■				□		
400/213		2	■	■	■								■	■	■				□		
400/22B		2				■	■						■	■	■				□		
400/26		2[4]						■					■	□	■						opt. async. adapter
Autoline 24		4						■						□	□						point-to-point,
Autoline 48		4							■					□	□						multi-drop, etc.
Autoline 96		4								■				□	□						four-port
Concord V.22		2				■							■		■				□		opt. eye-pattern gen.
V.22 bis	645	2				■	■						■	■	■				□		extensive diagnostics
V22bis ARQ	1095	2				■	■						■	□	■		■		□		
Superduplex	1495	2				■	■						■	■	■		■	■			three-way multiplexer
DaCom Buzzbox	70	2		■											□						very small
DSL2123	265	2	■	■	■							□		□	□			□	□		basic multi-standard
DSL2123AD	349	2	■	■	■							■	■	■	■		□	■			EPAD option
DSL2123GT	498	2	■	■	■							■	■	■	■	■	■	■		□	EPAD option
Datalines DL300	135			■																	acoustic coupler
801	150			◪																	acoustic coupler
802	160			■																	acoustic coupler
Minimodem 3012	175		■																		acoustic coupler
Viewdata set	63	2	◪		■																sim. to Prism 1000
Digisolve ChipChat	190	2	■	■	■							■	■	■	■			■			
Epson CX-21	160			■																	acoustic; battery
Gandalf DMV22	485					■									■				□		
DMV23D-AA	245				■										■				□		
DMV26L	315	2/4						■											□		
DM 49	750	4								■											1 or 2-channel
GEC Datachat 1223	78	2	■		■																line-powered
Datachat 1223A	125	2	■		■										■						line-powered
IAL 2424		2				■	■						■	■	■						
2412		4/2						■											□		
9620		4								■											point-to-point
9621		4								■											multiplexer

Maker, model	Price	2/4	View-	CCITT modes								Bell	Soft	Auto-		Hayes	Error	Buf-	Rack	Data	Comments
	£	wire	data	21	23	22	/b	26	27	29	32	modes	ctrl	dial	ans	cptbl	corr.	-fer	mtg	security	
IBM 3863		2/4						bis					■		■		■		□	■	data networks
3864		2/4							ter				■		■		■		□	■	
3865		4								■			■				■		□	■	also multi-point use
Interlekt Prospect	125	2	■	■	■							■									low-cost model
Portman	173	2	■	■	■							■			■			□			weatherproof model, £220
SB321	179	2		■										□	□		□	□			low-cost range
SB2123	230	2/4	■	■	■									□	□		□	□			
SB1223	179	2/4			■									□	□		□	□			fast carrier turn-off
SB1212	495	2				■								□	■		□	□			interface display
SB2426	317	4/2						■						□	□		□	□			
Berkeley	350	2	■	■	■							■	■	■	■			■			menu-driven
Jaguar DM 49	895	4								■											1 or 2-channel
1212	495	2				■								□	■	□	□		□		
2424	645	2				■	■							□	■	□	□				
2426	350	4/2						■						□	□	□		□	□		
Kirk Magic Modem	59	2	■	■	■							□	□	□				□			very low cost
Master Systems 21/23	195	2	■	■	■										■						low-cost model
21/23iAD	295	2	■	■	■							■	■	□	■		□	□			
2/12 SA	495	2				■							■	□	■				□		
2400	495	4/2						■						□	□				□		self-test
Micom-Borer 3012	255	2	■	■	■									□	■		□		□		
3012/V.22	525	2				■								□	■		□		□		
3024	780	2				■	■							□	■		■				
4012	235	2/4	■	■	■																
4024/ASYNC	475	2				■	■							■							
4024/LL	495	2/4						■/bis						■	□						
4048/V.27+	1350	2/4							■/bis/ter												data networks,
4096/V.29+	2195	4								■			■	■							multi-point etc.
4096/4+	2195	4								■			■	■				■			four-way multiplexer
Black Box V.21	96	2		■																	
AC	205			■																	acoustic coupler
2123	395	2/4		■	■								■	■	■						
V.21/V.23	255	2[4]	■	■	■										□				□		
V.22	550	2				■									■						
1212	750	2				■								■							
V.26 async	475	2/4						■													sync version £495
V.27	895	2/4							■/bis/ter				■								
V.29	1575	4							■	■			■								small size
MicroScope		2	◪												□				■		viewdata host
Miracle WS2000	130	2/3	■	■	■							■	□	□	□						low-cost model
WS3000 V2123	295	2/3	■	■	■	□	□					■	■	■	■	■		■		□	security option, £98
WS3000 V22	495	2/3	■	■	■	■	□					■	■	■	■	■		■		□	
WS3000 V22bis	650	2/3	■	■	■	■	■					■	■	■	■	■		■		□	
Modular Technology																					
Minimodem 3005	85			◪																	acoustic couplers -
3005/1	90			■																	
3005/2	95			■								□									battery-powered
3012	95		◪																		viewdata version
Inter-Mover V.21	98	2		■																	
Inter-Mover V.23	115	2	■		■																
Inter-Mover V.22	tba	2				■															
M4023	>187	2/4	■	■	■							■		□	■						
Pace Nightingale	119	2	■	■	■							■	□	□	□						low-cost model
Prism Modem 1000		2	◪		■																from Modem House etc.
Modem 2000		2	◪		■								■								from Modem House etc.
Racal-Milgo MPS3021		2		■											■				□		
CP2123		2	■	■	■							■	■	■	■						
MPS1223		4[2]	□		■									□	□				□		opt'l sync. converter
MPS1222		2				■						■		□	■				□		
MPS24		2/4						■/bis						■	■				□		opt'l sync. converter
MPS2426		2/4						■					■						□		low-speed 2ary chan'l
VI2422		2		■		■	■						■	■	■						dial back-up
Omnimode 48		4							■/bis				■						□	■	for data networks,
Omnimode 96		4								■			■						□	■	network management,
Omnimode 14.4		4									V.33		■						□	■	multi-port
Alpha 96		4								■			■								multi-drop lines etc.
Alpha 96 Plus		4								■			■								multi-port version
RS Components V21	98	2		■																	
V23	115	2	■		■																
V21/V23	245	2	■	■	■								■	■	■	■		■			speed-sensing
acoustic V21	139			■																	rechargeable battery
Steebek Minimo	96	2	□	■	□							□									basic models
Minimo Plus	195	2	■	■	■							□	□	□	□	□		□			
SB321	179	2		■										□	□	□			□		
SB1212	495	2				■								□	■	□	□		□		
SB1223	179	2[4]			■									□	□	□			□		
SB2123	230	2[4]	■	■	■									□	□	□		□	□		
SB7512,1275	179	2	◪											□	□	□		□	□		viewdata host/term'l
SB2426	317	2/4						■						□	□	□	□	□	□		
Quattro	795	2	■	■	■	■	■					□	□	■	■	■	■	■	□	□	
Tandata Tm110	99	2	◪		■								■	■							viewdata terminal
Tm200	173	2	■	■	■								■	■	■						
Tm512	245	2	■	■	■								■	■	■			■			
Tm602 Triple	465	2	■	■	■								■	■	■			■			auto diagnostics
Telindus Daisy 21		2		■										□	□						
Daisy 23		2	■											□	□						
Dahlia		2/4						■/bis						■	■					■	opt. 75 bit aux chan
Hyacinth		2				■	■					■	■	□	■				□		l.c.d. readout
Iris 2123		2/4	■	■	■							■			■				■		error test feature
Iris Videotex		2	◪											■							viewdata terminal
Lotus series		4/2							■	■				□	□				□	■	six models
Narcis		4						■					■						□		for IBM3600/4700 loop
V21 LSI		2		■																	modem card
V26 LSI		4						■					■								modem card
Transam M1	375	2	■	■	■							■	□	□	□		■	■		■	for cellular radio
Viccom	89	2	■	■	■							■		□	□						dial/answer board £40

Key -- ■ feature provided in basic model; □ optional feature; ◪ originate-only or answer-only. Prices exclude v.a.t.

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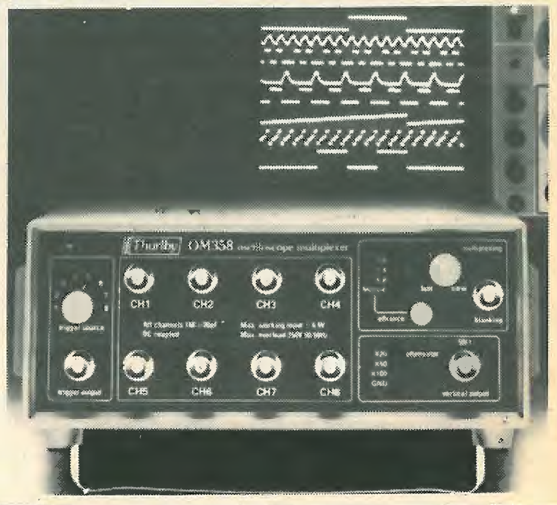
New Road, St.Ives, Huntingdon,
Cambs. PE17 4BG, England. **Tel: (0480) 63570**

CIRCLE 33 FOR FURTHER DETAILS.

Add 8 channels to your 'scope

New Thurlby OM358 multiplexer £179+vat



The Thurlby OM358 gives any oscilloscope an 8 channel display. Observing many waveforms simultaneously can be essential when analysing sophisticated equipment. Application areas include microprocessor based products, data transmission systems, A to D converters, frequency synthesizers etc.

The OM358 is ideal for digital equipment (it can often solve problems that would otherwise need a fast logic analyser) but, unlike dedicated logic test instruments, it is equally suited to analogue waveforms.

The OM358 has a bandwidth of 35MHz and 3% calibration accuracy. Each input has an impedance of 1MΩ - 20pF and accepts signals up to ±6V. An 8 channel, 4 channel, or single channel display can be selected with triggering from any channel. *Colour data sheet with full specifications available.*

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CIRCLE 34 FOR FURTHER DETAILS.

The world's most advanced low-cost bench multimeter!

Thurlby 1905a £349+ VAT

A complete high performance bench DMM

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- Full ac and current functions as standard

A sophisticated computing and logging DMM

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- Percentage deviation; running average
- dBV, dBm general logarithmic calculations
- Limits comparison; min and max storage
- 100 reading timed data logging
- RS232 and IEEE-488 interface options

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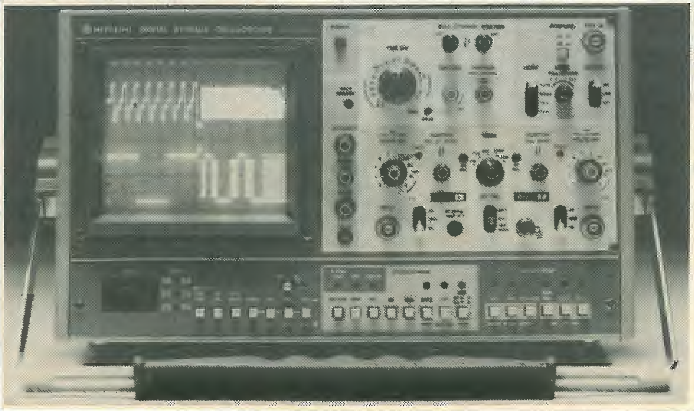
Thurlby
designed and built in Britain

CIRCLE 35 FOR FURTHER DETAILS.

Digital storage oscilloscopes from Hitachi

more speed, more memory, more features



The new Hitachi VC-6041 combines a 40MHz A-D converter with 8K words of acquisition memory to provide ultra high resolution capture of high speed transient events.

A wealth of state-of-the-art features includes signal averaging, roll mode, variable pre-trigger, post storage expansion to X100, digital voltage and time readout, pen recorder output, and a GPIB data option.

If your application is a little less demanding choose the VC-6015, it's the easiest to use digital storage 'scope around. It has dual channel storage at 1MHz clock rate, 2K word memory, variable pre-trigger, X10 post storage magnification and a full pen recorder output, yet it costs only £1,350.

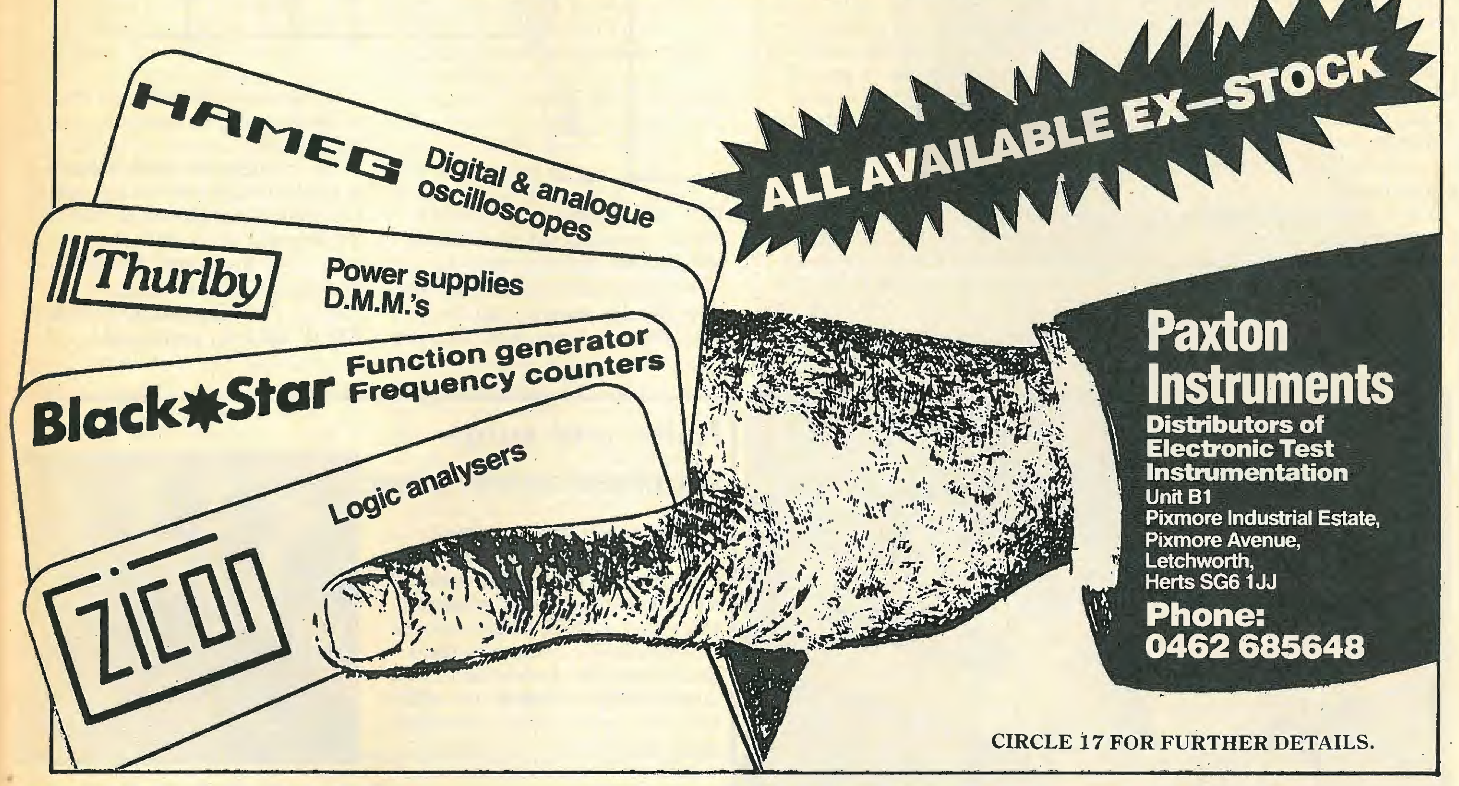
We hold the complete Hitachi 'scope range in stock for immediate availability. Ring us now to get full specifications and prices or to arrange a demonstration on **(0480) 63570.**

Thurlby-Reltech Instruments, 46 High Street, Solihull, W.Midlands, B91 3TB

CIRCLE 36 FOR FURTHER DETAILS.

A FULL HOUSE

DISTRIBUTING A GREAT DEAL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CIRCLE 17 FOR FURTHER DETAILS.

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. . . and they're affordable too!!

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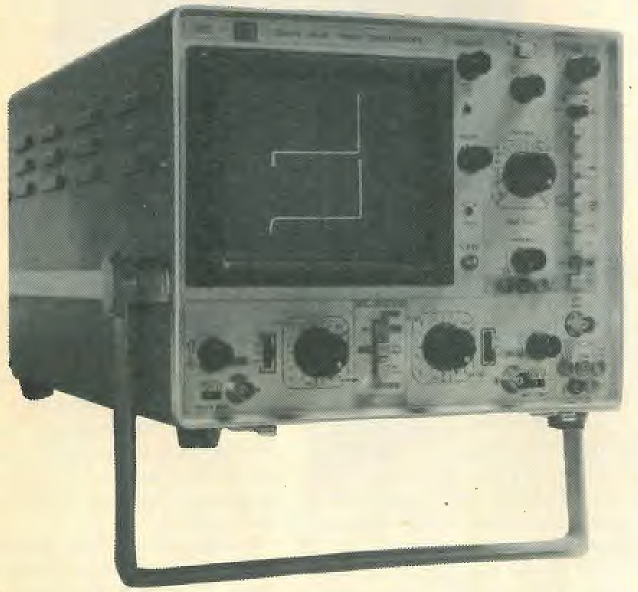

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- ✱ Component Comparator
- ✱ Triple Output DC Source

plus. . .

- ✱ 20MHz Bandwidth
- ✱ 2mV/div Sensitivity
- ✱ 40ns/div Timebase
- ✱ TV Frame and Line Trigger
- ✱ Add and Subtract
- ✱ X – Y mode

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32/10/4/1

CIRCLE 24 FOR FURTHER DETAILS.

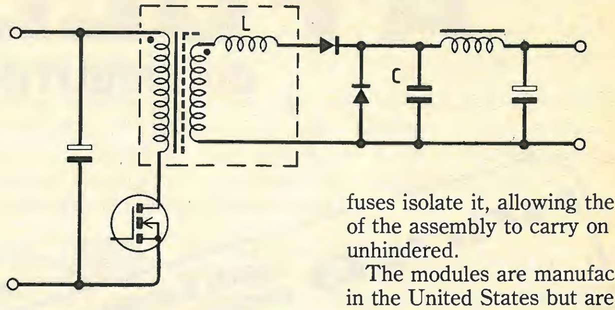
Chocolate-bar s.m.p.s.

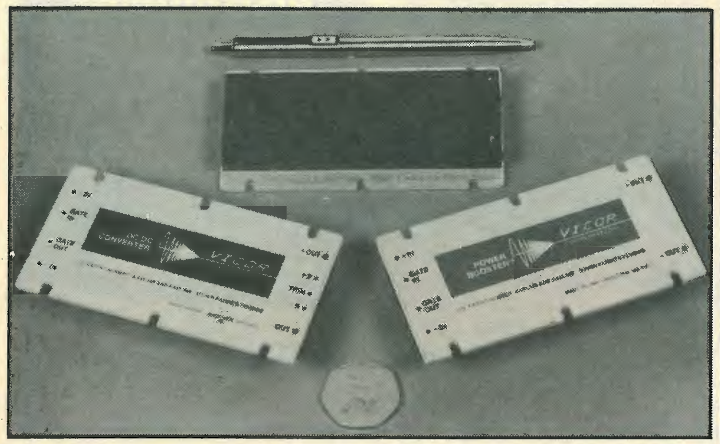
If you increase the chopping frequency of a switch-mode power supply, you can make it much smaller by slimming down bulky inductors. The miniature power supply is an appealing thought, but until it has been frustrated by the inevitable increase in switching losses, a major cause of which is leakage inductance in the transformer.

Yet in a novel range of d.c. converters from Vicor Corporation, this undesirable parasitic element (L in the diagram) has been turned into a virtue by resonating it with a capacitor, C. The result is a forward converter which generates not square waves but half-cycles of sine wave. As the current now rises more slowly at the instant of switching, power loss is greatly reduced. The mosfet switching element of the Vicor module chops at around 1MHz, making it possible to pack the entire assembly, p.c.b. and all, into a module the size of a bar of chocolate. Even at this frequency, an efficiency of 80% is quoted.

Modules are offered in 50, 75 and 100W versions with nominal input voltages ranging from 12 to 270V and outputs from 5 to 48V. For a.c. points, a simple bridge rectifier and capacitor must be added. For higher powers, 200W slave booster modules can be paralleled up. If one fails, internal fuses isolate it, allowing the rest of the assembly to carry on unhindered.

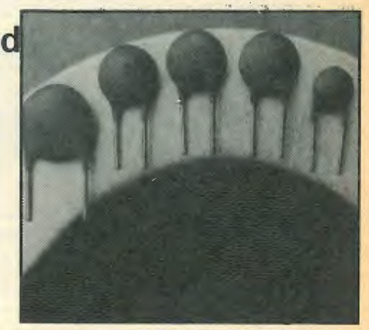
The modules are manufactured in the United States but are due to be second-sourced shortly from the Republic of Ireland. One-off price is currently less than $200. Powerline Electronics Ltd, 5 Nimrod Way, Reading RG2 0ED. **EWW 221** on reply card.





Noise and surge suppression combined

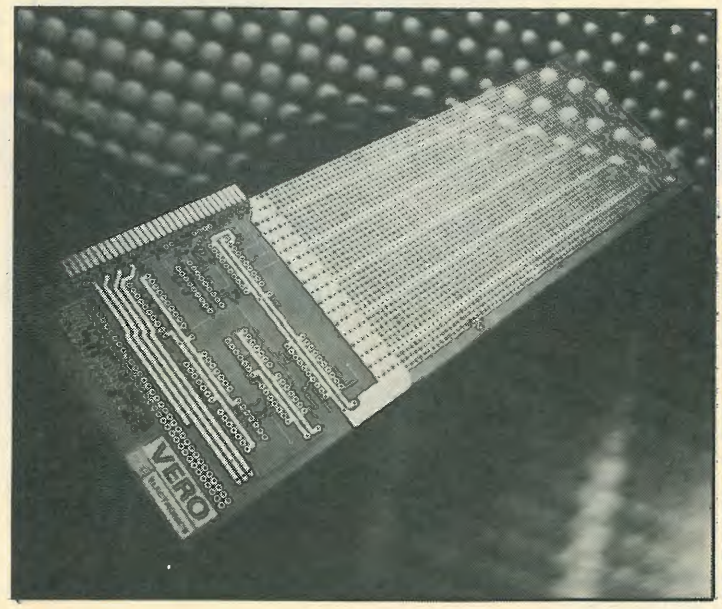
Disc ceramic capacitors are available which incorporate varistors, and can thus provide simultaneous noise and surge protection within a single two-terminal device. Known as the BCV range, the devices have direct voltage ranges of 9 to 25V with the corresponding varistor range of 18 to 45V. Capacitance values are from 2200pF to 0.47μF and the BCV operates between −25 and +85°C at ±20% capacitance tolerance. The smallest in the range has a 4mm diameter while the largest is 10mm wide, all 3mm thick. Murata Erie Electronics (UK) Ltd, 100 Albert Street, Fleet, Hants GU13 9RN. **EWW 217** on reply card.

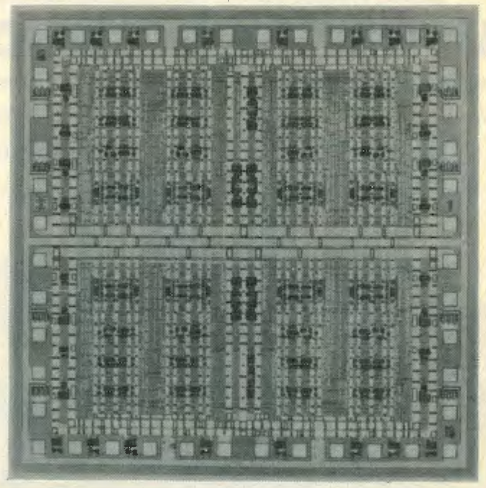


Prototyping board for PCs

Although the number of add-on boards for the IBM PC is increasing almost daily, it may be that you need to develop one for a specific task which is not already made. BICC-Vero have made this a lot easier by providing two prototyping boards which will plug into the PC's expansion slots. One provides normal solder pads for hand wiring, the other provides low-profile terminals for use with Vero's Speedwire pen. The use of normal wire-wrap terminals is not possible as there is insufficient space between the expansion slots on the IBM computers. Both boards have plated-through holes.

BICC-Vero Electronics, Unit 5, Industrial Estate, Hedge End, Southampton, Hants SO3 3LG. **EWW 213** on reply card.





GaAs cell array

Semi-custom circuits of medium-scale integration in gallium arsenide are now possible with the use of a Harris cell array. The HMD-11100 array has the equivalent of 300 gates and can achieve switching rates up to 3GHz, said to be 50% faster than other GaAs cell arrays and five times faster than similar circuits with silicon e.c.l. gates.

The device is a fixed-location array, with 48 AND gates, eight NOR gates, eight D-type flip-flops, six clock drivers/differential amplifiers, along with 16 input buffers and eight output buffers, all with fixed positions. They are interconnected by two metallic layers which are configured to provide the required functions. Harris claim to be able to provide completed circuits 16 weeks after a customer's layout is received and audited.

Further details from Harris-MHS Semiconductor, Eskdale Road, Winnersh, Wokingham, Berks RG11 5TR. **EWW 206** on reply card.

68000 computer with new bus

A superfast British computer runs a Motorola 68000 16/32-bit processor at 12MHz. Gemini Computers, who developed the 80-bus system for Z80-based computers, have continued their philosophy of concentrating on bus-based systems and in Challenger 20 they have devised a new bus called 68K-bus. (VME, Gemini say, offers overkill and is expensive to implement; other buses commit the user to various combinations and sizes of Eurocards that are difficult to house vertically.) The system is based around the c.p.u. backplane design which combines several functions, containing c.p.u., ram, disc control, i/o and of course the backplane for connecting further cards. The bus and cards have been designed so that future 32-bit developments may be incorporated.

Using GM3001 c.p.u. backplane, Challanger 20 also incorporates a floppy disc drive, a 20Mbyte hard-disc drive with controller and power supply. There are four slots for expansion cards, and the bus is carried through a socket to the outside of the case so that a further backplane may be added or development cards can be plugged in directly. The computer incorporates 512K of dynamic ram, two RS232 serial ports, a Centronics parallel port and a battery-backed real-time clock.

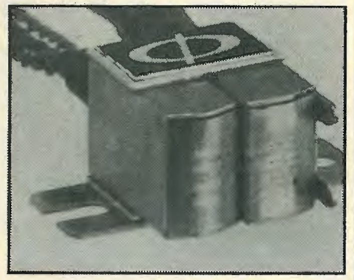
To complement the new computer and promote the 68K-bus, Gemini have a number of additional boards: four graphics circuits based around the Hitachi 63484 c.r.t. controller; a modem, 1 or 2Mbyte ram boards and serial interface boards. Full details of the bus are available in the hope that other manufacturers will adopt it and produce compatible peripheral equipment. The computer is offered with a choice of operating systems including CP/M68K, BOS and the p-system. Gemdos is to be added and a further c.p.u. card is being developed to run Unix.

Gemini Computer System Ltd, Springfield Road, Chesham, Bucks HP5 1PU. **EWW 220** on reply card.

Four-channel magnetic tape head

Claimed to be the first four-channel magnetic tape head, the CR44R44P1 audio cassette head is designed and built in Britain by Phi Magnetronics. The tape head allows tape monitoring on each of four independent tracks at the same time, particularly useful in sound mixing systems and communications monitoring equipment. Dimensions of the head conform to EIAJ standards and it can be interchanged with existing heads on the majority of cassette tape transports. Record and replay sections are completely independant, each with a screened case with head pole gaps optimized fo their specific function.

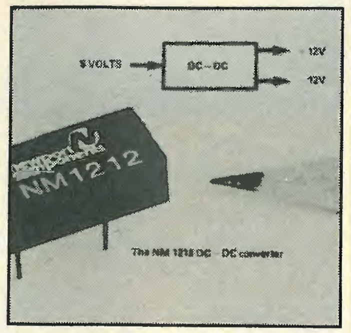
Available from Monolith Electronics Ltd, 5 Church Street, Crewkerne, Somerset TA18 7HR. **EWW 216** on reply card.



Miniature d.c. converters

Eliminating the need for multiple power supply systems and complex power bus lines on p.c.bs, the NM1212 and NM1515 are 5V to ±12V and ±15V converters that provide localised on-board power. Application at the point of load also improves overall performance by reducing noise and decoupling problems.

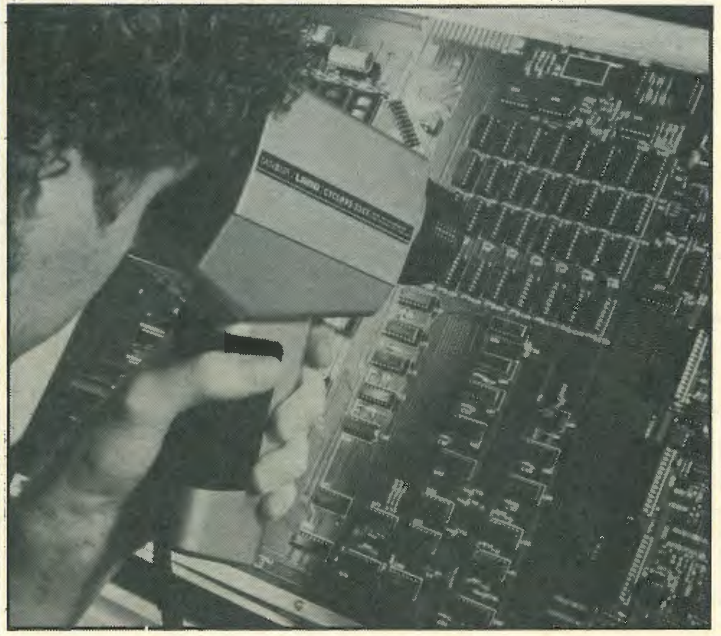
The package occupies 206mm^2 of board space and is only 7mm high yet delivers up to 300mW of power. The device operates between 0 and 70°C with no derating of the output current and with 70% efficiency. Newport Components Ltd, 134 Tanners Drive, Blakelands North, Milton Keynes MK14 5BP. **EWW 215** on reply card.



Infra-red spot thermometer

Cyclops, a range of infrared thermometers from Land Infrared, now includes the Minolta/Land Cyclops 33CF, which is designed to make spot measurements. It uses a fixed-focus Minolta lens of 170mm, and diameter of the measuring circle with the lens in focus is 2mm.

One views the target through camera-type reflex optics, which defines the target area and presents the digital temperature reading when the trigger is pressed. Range is −50 to +600°C. Readings are continuous, peak temperature hold or valley hold and an internal calculator is able to show mean, maximum or minimum of a series of readings, which are also presented at anoutput for connection to a data logger, printer or computer. Land Infrared Ltd, Dronfield, Sheffield S18 6DT. **EWW 219** on reply card.



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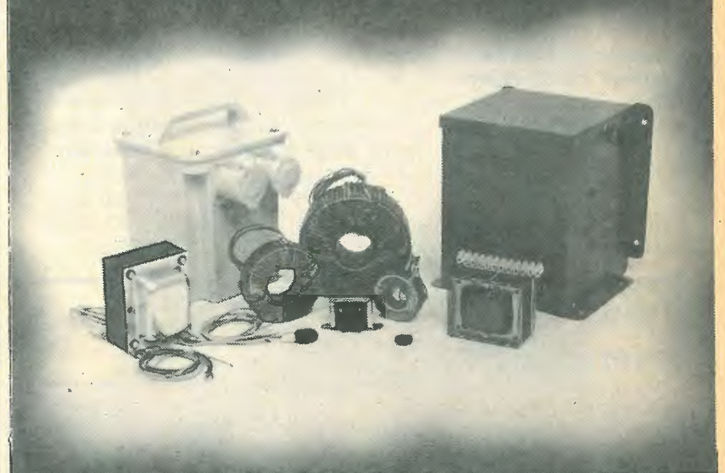

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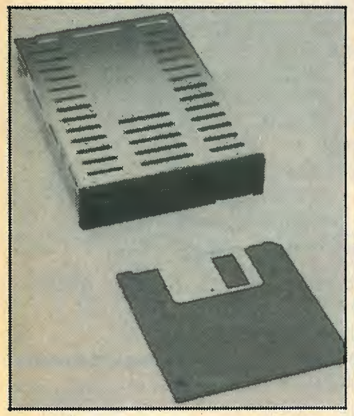
Slimline disc drive

Claiming to be the world's slimmest is the Epson SMD-280 drive for 3.5in floppy discs. At only 25mm high it is suitable for portable computers and with a power requirement of only 1.6W at 5V may be used with smaller, and simpler power supplies. It offers an unformatted capacity of 1Mbyte with a track-to-track access time of 3ms. It has a chucking hub for centering the disc and a drive pin structure (patent pending) to ensure accurate index pulse timing. Epson (UK) Ltd, 388 High Street, Wembley, Middlesex HA9 6UH. **EWW 207** on reply card.

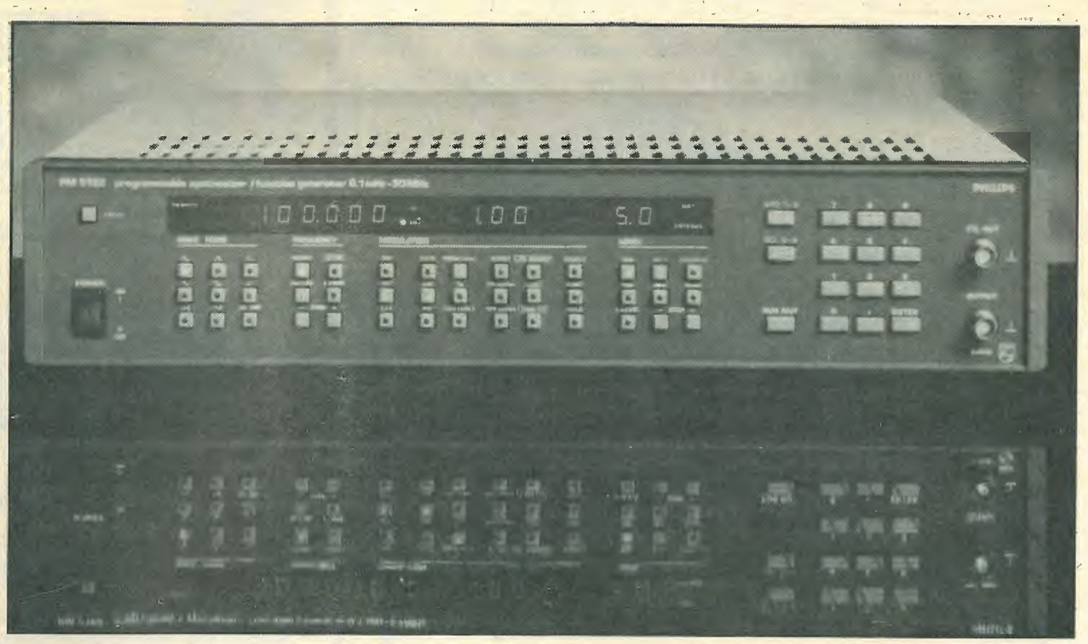


C-mos 68000 processor runs at 1/10 power

Motorola and Hitachi are jointly manufacturing an advanced c-mos version of the 68000 microprocessor which requires less than 40mA supply current operating with no load at 12MHz. This power reduction means that it is now possible to add the feature of portability to computers.

In consuming less power, the c-mos 68000 is more reliable than its n-mos counterpart. High-density c-mos devices are also less susceptible to damage from static electricity than i.cs made using earlier c-moss processes, and noise immunity is of c-mos i.cs is good. Cooler devices however allow moisture seepage more readily than higher-powered ones but this problem is greatly reduced by recent advances in plastics i.c. package design. Lower operating temperatures mean higher integration and smaller end products.

Samples of ceramic dil and pin-grid-array c-mos 68000 processors are available and mass production is expected to start in the first quarter of 1986. By the second quarter, plastic dil and chip-carrier types will be available. Initially prices will be about twice those of equivalent n-mos parts, eventually falling to about 20% higher. **EWW 223** on reply card.



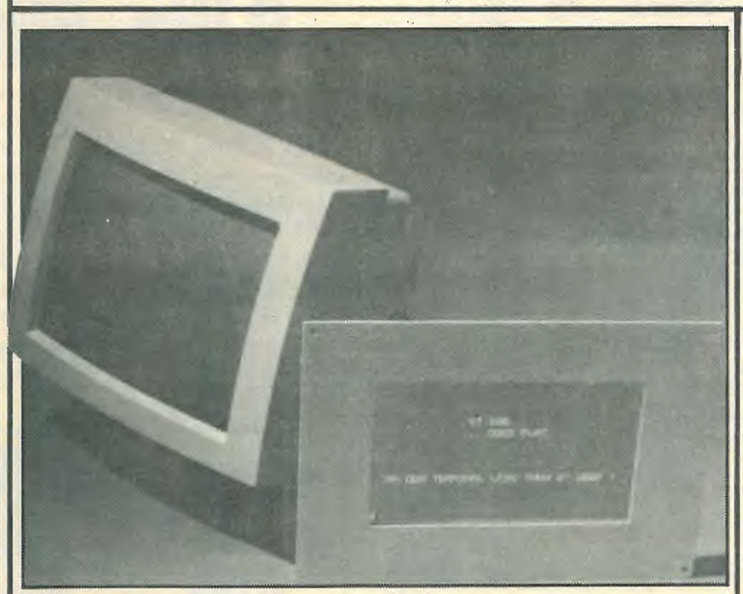
Programmable frequency synthesizer/function generator

A programmable or self-contained 50MHz frequency-synthesized signal generator, type PM5193 from Philips, provides eight waveforms in the range from 0.1 to 50MHz. With frequencies referred to a crystal oscillator and settable to within 1 in 10^6, the instrument can be set to sweep between key-selections. Waveforms provided are sine, positive or negative pulse, square, triangle, haversine, positive and negative sawtooth.

Modulation is internal or external a.m., f.m. or non-phase-related gating, and internal frequency sweep and phase-related burst.

Numerical displays indicate frequency setting, modulation, output level and status, and all front-panel settings can be committed to the controller's memory when in the IEEE bus mode and recalled by sending a simplified string corresponding to the settings. Up to ten front panel settings can be stored internally in a non-volatile memory for later recall.

PM5193 costs £2995, plus vat, and is handled in the UK by Pye Unicam Ltd, York Street, Cambridge CB1 2PX. **EWW 218** on reply card.



Slimline terminal

A flat-screen display that is 51mm thick offers full emulation of the VT100 terminal. The high-resolution d.c. plasma panel has 640 by 400 picture elements with a high-contrast orange display, completely free from flicker. All the usual terminal facilities are available including double-height and/or double-width characters on a display format of 80 columns by 24+1 lines. The screen may be split and it is possible to give a smooth continuous scroll or jump from page to page. The controller has built-in decoding for both a qwerty keyboard and a touch panel. Power consumption is 25W. From Perdix Components Ltd, Unit 4, Airport Trading Estate, Biggin Hill, Kent TN16 3BW. **EWW 208** on reply card.

Transputer evaluation systems

Evaluation boards, holding a 32-bit Transputer, memory and two RS232 ports, are available from Hawke Electronics and Rapid Recall and range in price from £1700 to £2100 (see News for further details).

The Transputer, designed to run in multiprocessor applications, is capable of executing ten million instructions per second and each instruction is only one byte long, which makes programs compact. A language called Occam specially designed to exploit the Transputer's concurrent processing capabilities has been in use since 1983.

Link adaptors consisting of a single c-mos i.c. for linking the Transputer to standard eight-bit peripherals cost between £30 and £42 and development software for Stride 440 or Vax computers is £3300.

Further boards for connecting to the IBM PC at £2900 with 1Mbyte memory or £3300 with 2Mbyte memory are expected to be available in November as is development software for the PC costing £3000. **EWW 222** on reply card.

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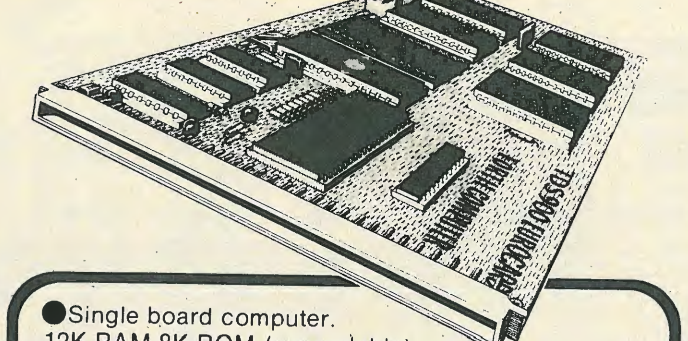

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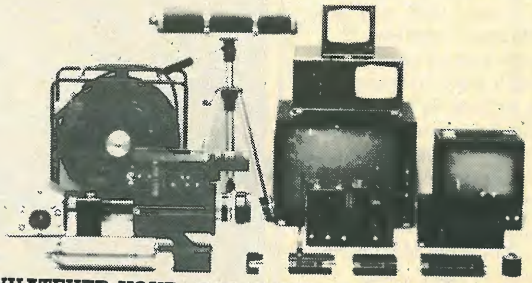

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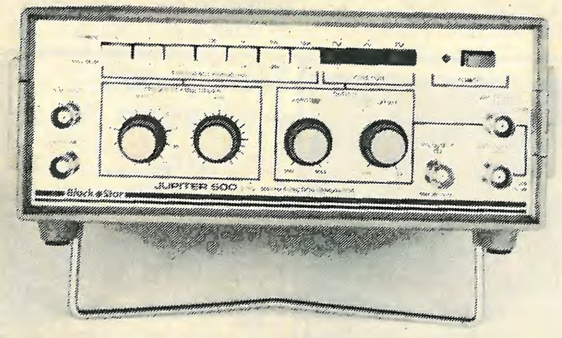

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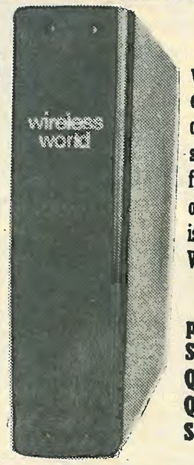

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Computer-controlled radio

Continued from page 44

Thirdly, and potentially the most serious of all, the manual aerial tuning potentiometer – which controls varicap diodes in the front end – requires different settings for different frequencies and different supply voltages. The only answer to this would seem to be either direct control of the varicap voltage by the computer, perhaps from a d-to-a converter with a software feedback loop to find the optimum tuning point, or by switching a number of preset potentiometers across the existing control. The second option is likely to give better results although it has not been tried.

For these reasons no attempt has been made to calibrate the aparatus. It would of course be possible to provide, for example, a crystal oscillator rich in harmonic output and previously calibrated against an r.f. voltmeter or spectrum analyser. Harmonics close to the frequencies of interest could be used as a reference for arithmetic correction of the measured readings prior to data storage. However, whilst this would undoubtedly make the equipment more useful, it seems to be moving away from the original cheap and simple concept. In many cases it is sufficient to detect the presence of a transmission without worrying about its absolute strength.

Because data is stored on disc, it is a relatively simple matter to dump it via a modem down an ordinary telephone circuit. To do this, the remote computer must be re-configured to "auto-boot" a simple RS423 terminal program on power-up (or after the inevitable power cut!). The strapping of a link on the keyboard achieves this and is well documented on page 80 of the disc system user guide (ref. 3). Proprietary software such as COMMSTAR may be used at both ends with a short interrogation and control program at the local computer to use error-correction protocols. Taking readings at two-second intervals about 40K of data is generated in 18 hours, which dumps down in as many minutes at the end of the day. Typically, such files are received without detectable errors at 300 baud.

Such a system has been experimentally tested at Radio Botswana with great success. It is possible to send direct commands and even modifications to the data logging program to the remote computer (example programs are available on request). Thus the program can be run and stopped at will and manual intervention is not needed at all at the remote end.

Books

The BBC Microcomputer in Control: Interfacing Projects for Beginners, by Paul Beverley, Nigel Eames and Geoff Osborne. Prentice/Hall International, 150 pages, soft covers, £7.95. The BBC Micro is still the best computer for the experimenter; and with plans for a variety of simple projects, the Beeb buffs of Norwich City College show you how to get started. Their selection includes relay drivers and power switches, a sound-to-light system, a logic probe and a slot-car timer, all with relevant software in BBC Basic. An interesting section on communications explains how to modify a mains-borne intercom system to make it carry computer data. There is a chapter on construction techniques for those new to the soldering iron. Irresistible Christmas present for computer kids.

Practical repair and maintenance of communications equipment by Albert D. Helfrick. Prentice/Hall International, 308 pages, soft covers, £15.40. Trouble-shooting methods for radio communications hardware of all kinds, professional and amateur. With the help of many illustrations, the author describes the circuit elements found in modern equipment, the faults to which they are prone and the instruments you can use to examine and repair them.

Radio Database International – Part 1: International Broadcasting Edition, edited by Lawrence Magne and Tony Jones. International Broadcasting Services, 240 pages, soft covers, ISBN 0-914941-01-1.
A remarkable achievement: a channel-by-channel, hour-by-hour plan of the high-frequency broadcasting bands.

Some 200 pages of neat computer-generated charts list the occupants of each channel and the source, target area, language and power of each transmission. The information is compiled from actual monitoring observations by a worldwide team of contributors and includes details not to be found in published schedules, such as clandestine stations and jamming. At the back of the book is a review section describing a dozen top-of-the-range h.f. receivers.

For the enthusiastic listener, the charts make a valuable adjunct to the well-established World Radio TV Handbook. But they do not replace it, since they offer no direct way of tracing the individual broadcaster's schedules.

Part 2, of 59 pages (ISBN 0-914941-02-X), covers the tropical bands from 2247kHz to 5720kHz. The parts are published separately but can be obtained together at $12.95 (plus $1.95 for surface postage outside North America or $8.95 for air mail): International Broadcasting Services Ltd, P.O. Box 300, Penn's Park, Pennsylvania 18943. There are plans to revise the guides annually.

The Advanced Disk User Guide for the BBC Micro by Colin Pharo. Cambridge Microcomputer Centre, 446 pages, ring bound, £14.95. Uniform in style with the same publisher's Advanced User Guide, this new volume covers the Acorn disc filing system with the same authority and attention to detail.

Early chapters cover the Acorn disc format, the 8271 floppy disc controller and the command list and memory usage of Acorn's DFS 0.90. Forming the core of the book is a lengthy reference section which describes the many DFS system calls one by one and illustrates most of them with example programs – information which will be of enormous value to the machine-code programmer.

A section on file-handling techniques explains the possibilities of index files and hashing algorithms and provides a useful introduction to the theory and practice of database construction.

Also included are listings of several disc utility programs, accompanied by full explanations of their workings: an overlay program, a special formatter to produce combined 40/80-track discs, a program to recover deleted files and a sector-editor.

The original Acorn DFS, which forms the bulk of the book's subject matter, is undoubtedly one of the weak points of the BBC machine, possibly the weakest. Despite this, the author says hardly anything about disc filing systems from competing suppliers.

BBC designs

Continued from page 6

through major projects by the transmission group alone are likely to exceed £3M against a cost of just £1.85M. Furthermore, these figures do not take account of BBC Engineering's invovement in the BBC Microcomputer project, which has brought the corporation more than £12M in royalties.

A BBC idea newly launched commercially is Datacast, an information system which makes use of spare capacity in the teletext lines. Datacast could be useful to organizations such as financial institutions or bookmakers who need rapid nationwide distribution of data. The extra information stream is fitted into packets 29 and 31 of the teletext signal, where it is inaccessible to ordinary teletext sets. But the BBC's demonstration receiver, an Acorn teletext adapter with special software, showed the speed (1500 characters per second) and the very low error-rate possible with the system.

If Datacast turns out to meet a need, transmissions could be greatly expanded by the introduction of full-field teletext during the night.

On the microelectronics front, Designs Department has adopted the TMS 32010 microprocessor for digital audio signal processing. This device is fast enough to perform useful tasks in real-time. Especially attractive to the audio designer is its built-in hardware multiplier, which can multiply two 16-bit numbers in 200ns, making the chip suitable for a variety of uses in mixers and filters.

Other developments in digital audio have continued with further work on the BBC's Nicam-3 encoding equipment. It has turned out that the l.s.i. chip produced for encoding digital stereo sound-in-syncs is fast enough to code six channels, with help from a Z80. So savings will be possible in the cost of expanding the p.c.m. radio distribution network and of replacing the original 13-channel linear p.c.m. equipment.

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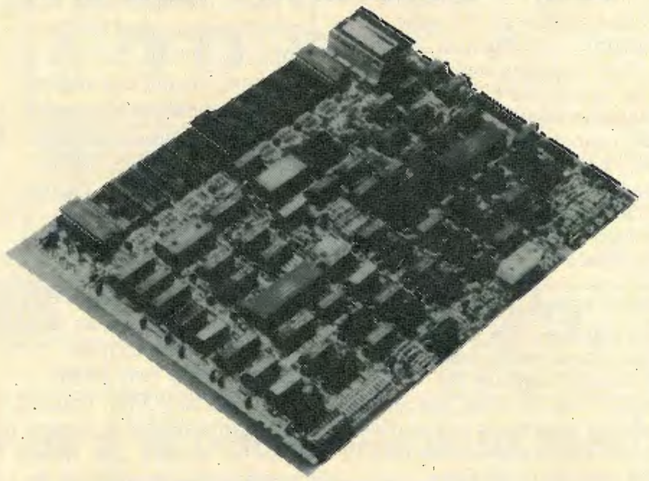

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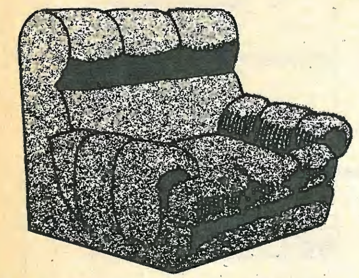

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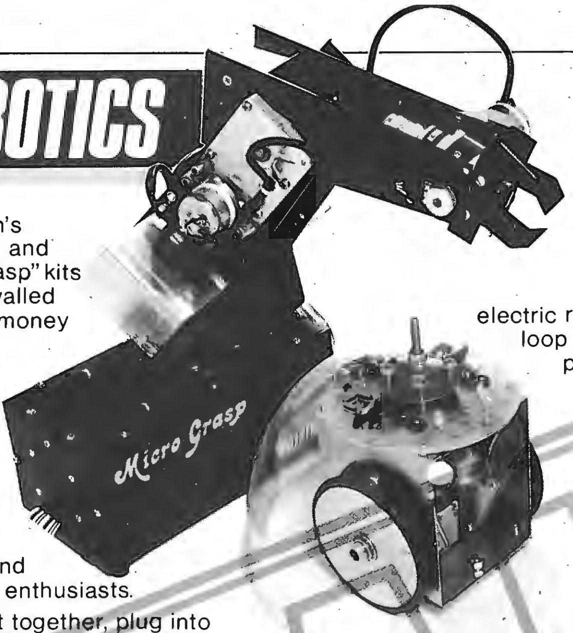

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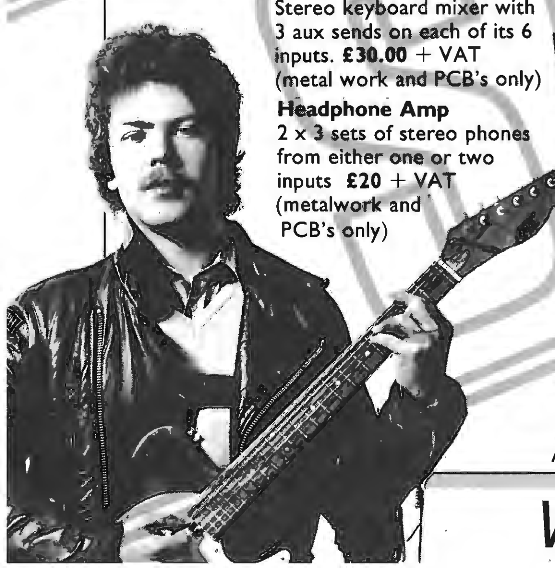

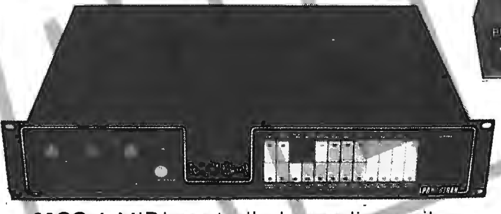

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